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Vol. CXXXV.—No. 3517] LONDON: FRIDAY EVENING, MAY 25, 1923 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director - General, India Store Department, Branch No' 15, Belvedere-road, Lambeth, S.E. 1. REQUIRES :—
TUBING, WROUGHT IRON OR MILD STEEL, GALVANISED.
Tenders due 2 p.m., 15th June, 1923.
Tender forms obtainable from above. 2550

The Government of Zanzibar has FOR SALE GENERATING PLANT, consisting of Three Bellis and Morcom Enclosed Compound Engines, 18in. and 22in. by 9in. strokes, 400/420 r.p.m., designed to give 260 B.H.P. at 125 lb. steam pressure, direct coupled to Compound Wound D.C. Generators, by the Electric Construction Co., to give 175 K.W. at 240 volts. Also Four Smoke-tube Boilers, each 150 H.P., One Wheeler Condenser, Water Heater, and Feed-water pumps.
This plant is at present at Zanzibar, but further particulars may be obtained from the CROWN AGENTS FOR THE COLONIES, Engineering Contracts Department, 4, Millbank, Westminster, S.W. 1.
Offers to purchase should be addressed to the CROWN AGENTS FOR THE COLONIES. 2493

District Engineer REQUIRED by the GOVERNMENT of NIGERIA for the RAILWAY DEPARTMENT (Capital Works), for one tour of not less than twelve nor more than eighteen months, with possible extension. Salary £720 a year, rising to £920 a year by annual increments of £40 with a seniority allowance of £72 a year. Liberal leave in England on full salary. Free quarters and passages. Candidates, not over 45 years of age, must have had responsible charge of railway construction and possess a good knowledge of contract work.—Apply at once by letter, stating age and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Nig. 11,913. 2574

University of Birmingham.
JAMES WATT RESEARCH FELLOWSHIP.
The Council invites APPLICATIONS for the JAMES WATT RESEARCH FELLOWSHIP in the Thermo-Dynamics of Internal Combustion Engines. Candidates should hold an Honours Degree in Engineering of a British University, and have had some experience in research. The Fellowship has at present an annual value of £220 and is renewable. Applications should be sent in not later than 31st of May, 1923.
Further particulars may be obtained from the Dean of the Faculty of Science, The University, Edgbaston, Birmingham.
GEO. H. MORLEY, Secretary.
2414

The University of Sheffield.
PROFESSORSHIP OF MECHANICAL ENGINEERING.
The Council of the University invite APPLICATIONS for the above POSITION, shortly to become vacant.
Applications should be received by the undersigned, from whom further particulars may be obtained, by the 12th June.
W. M. GIBBONS, Registrar.
2532

Aberdeen Corporation Water-Works.
EXTENSIONS 1920.
CONTRACT NO. 10.—NEW AQUEDUCT.
The Town Council of Aberdeen are prepared to receive TENDERS from competent persons willing to enter into a contract for the MANUFACTURE and DELIVERY of about 3 MILES of 4ft. diameter PIPES and SPECIALS of the following alternative types, viz.:—
(a) Cast Iron.
(b) Mild Steel (Lap-welded).
The drawings may be inspected and specification, schedule of quantities and form of Tender obtained, on and after 30th May, 1923, on application at the Water Engineer's Office, 41½, Union-street, Aberdeen. Early application is desirable and no specification will be given out after 9th June.
For each specification of each type a deposit of Five Pounds sterling will be required, which sum will, after a Tender has been accepted, be returned to the tenderer, provided that he shall have sent in a bona fide Tender, based on the drawings, specification and schedule of quantities provided, with the schedule of quantities fully priced out in detail, and shall not have withdrawn the same.
Tenders, on the forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for New Aqueduct Piping," are to be addressed to the undersigned. No Tender delivered after 5 p.m. on the 22nd June, 1923, will be considered.
The Town Council do not bind themselves to accept the lowest or any Tender.
GEORGE MITCHELL, M. Inst. C.E., F.G.S., Water Engineer.
Water Engineer's Office,
41½, Union-street, Aberdeen,
21st May, 1923. 2543

Aberdeen Corporation Water-Works.
EXTENSIONS 1920.
CONTRACT NO. 11.—NEW AQUEDUCT.
The Town Council of Aberdeen are prepared to receive TENDERS from competent persons willing to enter into a contract for the TRANSPORTING, LAYING and JOINTING of about 3 MILES of 4ft. PIPING and ANCILLARY WORKS between Culter and West Cults.
The drawings may be inspected and specification, schedule of quantities and form of Tender obtained, on and after 30th May, 1923, on application at the Water Engineer's Office, 41½, Union-street, Aberdeen. Early application is desirable and no specification will be given out after 9th June.
For each specification a deposit of Five Pounds sterling will be required, which sum will, after a Tender has been accepted, be returned to the tenderer, provided that he shall have sent in a bona fide Tender, based on the drawings, specification and schedule of quantities provided, with the schedule of quantities fully priced out in detail, and shall not have withdrawn the same.
Tenders, on the forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for Aqueduct Pipe Laying," are to be addressed to the undersigned. No Tender delivered after 5 p.m. on 22nd June, 1923, will be considered.
The Town Council do not bind themselves to accept the lowest or any Tender.
No person should Tender unless thoroughly experienced in the actual construction of extensive public works.
GEORGE MITCHELL, M. Inst. C.E., F.G.S., Water Engineer.
Water Engineer's Office,
41½, Union-street, Aberdeen,
21st May, 1923. 25

The Engineer

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What Science Owes to Engineering.

A New Motor Road Roller.

PUBLIC NOTICES

Administrative County of London.
REPAIRS TO PAVEMENTS, BLACKWALL AND ROTHERHITHE TUNNELS.
TENDERS are INVITED for REPAIRS to the PAVEMENTS of BLACKWALL and ROTHERHITHE TUNNELS.
The specification, form of Tender, &c., may be obtained on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £3. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before payment of the fee.
No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 11th June, 1923, will be considered.
JAMES BIRD, Clerk of the London County Council.
2548

Administrative County of London.
SALE OF ELECTRICAL POWER STATION MACHINERY.
The London County Council invites TENDERS for the PURCHASE and REMOVAL of GENERATING SETS, BOILERS, COAL CONVEYOR, COOLING TOWER, FEED PUMPS, and WATER SOFTENING PLANT.
The plant may be inspected at the London United Electric Tramways Power Station, 74, High-road, Chiswick, between the hours of 10 a.m. and 4 p.m. on any weekday, except Saturday, from 4th to 11th June, 1923, both dates inclusive, by appointment with a representative of the Council.
Particulars and form of Tender may be obtained from the General Manager, London County Council Tramways, Victoria Embankment, W.C. 2.
Tenders must be delivered to the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, not later than Twelve Noon on Tuesday, 12th June, 1923. No Tender received after that time will be considered.
The Council does not bind itself to accept the highest or any Tender.
JAMES BIRD, Clerk of the London County Council.
2580

B. and C.I. Railway Company.
The Directors are prepared to receive up to Noon on Wednesday, 13th June, TENDERS for the SUPPLY of :—
(1) STEEL MATERIAL.
(2) COPPER FIRE-BOX PLATES.
(3) STEEL BOILER TUBES.
Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG, Secretary.
Offices : 91, Petty France, Westminster, S.W. 1,
17th May, 1923. 2547

County Borough of Portsmouth.
TENDERS are INVITED for :—
(a) The REMOVAL of a 60ft. ELECTRICALLY OPERATED BASCULE BRIDGE, and/or
(b) The PURCHASE and REMOVAL of same.
For further particulars and illustration of bridge see page 7.
F. J. SPARKS, Town Clerk.
Town Hall, Portsmouth,
17th May, 1923.

PUBLIC NOTICES

Amersham Rural District Council.
CHESHAM BOIS DRAINAGE, CONTRACT NO. 4
TO CONTRACTORS.
The Amersham Rural District Council are prepared to receive TENDERS for the CONSTRUCTION of about 2000 YARDS of STONEWARE and CAST IRON SEWERS of 7in., 9in. and 12in. diameter, together with MANHOLES, FLUSHING TANKS, and other appurtenant Works, in accordance with plans and specifications prepared by Messrs. John Taylor and Sons, Civil Engineers.
Copies of the specification and bill of quantities, with form of Tender, may be obtained and the drawings may be seen at the offices of the Engineers, 36, Victoria-street, Westminster, S.W. 1, upon payment of £5 (cheque only), which will be returned upon receipt of a bona fide Tender.
Sealed Tenders, endorsed "Chesham Bois Drainage," addressed to the undersigned at his offices, Amersham, before 10 a.m. on Friday, the 15th June, 1923.
The Council do not bind themselves to accept the lowest or any Tender.
By Order, W. J. STANDRING, Clerk to the Council.
2575

City of Leeds.
ELECTRICITY DEPARTMENT.
TURBINES, ALTERNATORS AND CONDENSING PLANT AUXILIARIES FOR SALE BY PRIVATE TREATY.
OFFERS are INVITED for the following PLANT, discarded to make room for larger sets :—
TWO 4000 B.H.P. HORIZONTAL REACTION TYPE STEAM TURBINES.
TWO MOTOR-DRIVEN THREE-THROW AIR PUMPS.
TWO MOTOR-DRIVEN CENTRIFUGAL PUMPS.
TWO 3000-KILOWATT TWO-PHASE ALTERNATORS and EXCITERS.
With the exception of one alternator, which requires repairs to the windings, the plant is in good working order, and it can be inspected by appointment.
Offers will be considered for the whole or any part of the plant. The specification, &c., may be obtained from the undersigned.
The Corporation do not bind themselves to accept any offer.
Offers are to be addressed to "The Manager, Electricity Department, 1, Whitehall-road, Leeds," C. NELSON HEFFORD, Manager.
1, Whitehall-road, Leeds,
22nd May, 1923. 2549

State Electricity Commission OF VICTORIA.
TENDERS FOR PLANT.
TENDERS are hereby INVITED for the SUPPLY, DELIVERY, &c., of the following for the Morwell Power Scheme.
Copies of Tender form and specification will be available upon application to
Agent-General for Victoria, Melbourne-place, Strand, London, W.C. 2.
SPECIFICATION No. 29/77.—ALUMINIUM STEEL-CORED CABLE, 0.0707 sq. in.
CHARGE.—£2 for the first three copies of Tender form, conditions of contract, specification complete. These charges will be returned on receipt of a bona fide Tender. A fourth copy and any further copies will be supplied for the sum of 10s. each.
PRELIMINARY DEPOSIT.—A preliminary deposit of £100 is to be lodged with the Tender.
The specification may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders, on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than 5 p.m., 31st August, 1923.
R. LIDDELOW, Secretary.
State Electricity Commission of Victoria, Melbourne, Victoria, Australia. 2572

PUBLIC NOTICES

East Indian Railway.
The Directors are prepared to receive up to Eleven o'clock a.m. TENDERS for the SUPPLY of :
(1) BUNTING and CANVAS ;
(2) GALVANISED EYE and STRAINING BOLTS and STRAND WIRE for FENCING ;
(3) LAMPS, GLASS, &c.;
(4) PAINTS, &c.;
(5) BALLAST WAGONS (Four-wheeled) ;
for Nos. 1, 2, 3, and 4 on Wednesday, the 6th June proximo, and for No. 5 on Wednesday, the 13th June proximo.
Copies of the specifications can be obtained at the Company's offices on payment of £1 1s. each. This fee will not be returned.
G. E. LILLIE, Secretary.
73-76, King William-street, London, E.C. 4.
24th May, 1923. 2592

The Great Indian Peninsula RAILWAY COMPANY.
The Directors are prepared to receive TENDERS for the SUPPLY of the following STORES, namely :—

	Fee for Specification.
4-WHEEL COVERED and OPEN WAGONS (with Rolled Steel Disc Wheels and Axles, Axle-boxes, and Laminated and Helical Springs)	£1

Specifications and forms of Tender may be obtained at this office on payment of the fee for the specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Great Indian Peninsula Railway Company.
Tenders must be delivered in separate envelopes sealed and addressed to the undersigned, marked "Tender for 4-Wheel Covered and Open Wagons," not later than Eleven o'clock a.m. on Tuesday, the 12th June, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE, Secretary.
Company's Offices,
48, Copthall-avenue, E.C. 2,
London, 23rd May, 1923. 2560

The Great Indian Peninsula RAILWAY COMPANY.
The Directors are prepared to receive TENDERS for the SUPPLY of the following STORES, namely :—

	Fee for Specification.
1. SOLID-DRAWN STEEL BOILER TUBES	10s.
2. CANVASES	5s.
3. PAINTS, DRYSALTERIES, &c.	10s.
4. STEEL WORK FOR BRIDGES	5s.
5. IRON OR STEEL SCREWS	5s.
6. WOOD HANDLES	2s. 6d.
7. LEATHER BELTING &c.	10s.
8. GALVANISED STAMPED STEEL MOTOR PANS	5s.
9. SPRING STEEL	2s. 6d.
10. CANVAS HOSE PIPES	10s.
11. GALVANISED WROUGHT IRON WATER TUBES, &c.	10s.
12. STATIONERY, &c.	5s.

Specifications and forms of Tender may be obtained at this office on payment of the fee for the specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Great Indian Peninsula Railway Company.
Tenders must be delivered in separate envelopes sealed and addressed to the undersigned, marked "Tender for Solid-drawn Steel Boiler Tubes," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 5th June, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE, Secretary.
Company's Offices,
48, Copthall-avenue, E.C. 2,
London, 23rd May, 1923. 2587

Messrs. George Cradock and CO., Ltd., Steel Wire and Wire Rope Works, Wakefield, beg to GIVE NOTICE that Mr. HORACE E. SMITH, formerly their Representative in the Midlands and South Wales, CEASED to REPRESENT them as and from 16th May last, and that he is not authorised to act on their behalf in any capacity whatsoever. 2582

"THE ENGINEER" WANTED.
WANTED, a COPY of "THE ENGINEER" Dated December 29th, 1919.—Address, P5090 The Engineer Office. P5090

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PUBLIC NOTICES

Port of Bristol.

NEW ELECTRIC CRANES, BRISTOL DOCKS.

The Docks Committee are prepared to receive TENDERS for the CONSTRUCTION of TWO 2-TON MOVABLE ELECTRIC JIB CRANES and the ERECTION of the same on the roofs of Sheds "Y" and "Z," Canon's Marsh, Bristol Docks.

On and after Thursday, the 31st day of May, 1923, copies of the general conditions, specification, schedule of prices, and contract drawing can be obtained from the undersigned on production of a receipt showing that a deposit of £3 has been paid to the Bristol Docks Committee, 19, Queen-square, Bristol, to whom all cheques must be made payable. The deposit of £3 will be returned hereafter to all bona fide tenderers.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Two Electric Cranes," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen-square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before 10 a.m. on Monday, the 2nd July, 1923.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE,
Engineer,
Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks,
23rd May, 1923. 257

Port of Bristol.

RECONSTRUCTION OF TRANSIT SHED "U," BRISTOL.

The Docks Committee invite TENDERS for the RECONSTRUCTION mainly in ferro-concrete of the DOUBLE-FLOOR TRANSIT SHED known as Shed "U," situate on Canon's-road, Bristol.

On and after Monday, the 28th day of May, 1923, a copy of the form of Tender, general conditions, specification, schedule of prices, and a copy of the contract drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the General Manager and Secretary of the Docks Committee, to whom all cheques must be made payable. The deposit of £5 will be returned hereafter to all bona fide tenderers.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Reconstruction of Shed 'U,' Bristol," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen-square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before 10 a.m. on Monday, the 18th day of June, 1923.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE,
Engineer,
Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks,
18th May, 1923. 2515

TO BOILERMAKERS.

The Undersigned is Instructed

(Robinson's oil gas fuel system) to obtain TENDERS for the CONSTRUCTION of a special STEEL STEAM BOILER and a PRESSURE GAS GENERATOR. Drawings and specifications can be had on application and payment of 10s. 6d. (not returnable). The lowest or any Tender not necessarily accepted.

A. C. FRANKLIN,
Engineer and Naval Architect.
80, Vauxhall-walk, London, S.E. 11. P7500

Department of Public Works
Sydney, 31st January, 1923.

SYDNEY HARBOUR BRIDGE TENDERS—EXTENSION OF TIME.

Tenders are Invited by the

Government of New South Wales for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of a CANTILEVER BRIDGE across Sydney Harbour from Dawes Point to Milson's Point, embracing a main span of 1600ft. in the clear, centre to centre of main piers, and a length of main bridge 2600ft. centre to centre of anchor piers. The total length of main bridge and approach spans included in Tender is 3810ft; also an ALTERNATIVE TENDER for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of an ARCH BRIDGE across Sydney Harbour from Dawes Point to Milson's Point, embracing a main span of 1650ft. in the clear, centre to centre of bearings. The total length of main bridge and approach spans included in Tender is 3770ft. Either bridge is to provide for four lines of railway, six lines of vehicular traffic, and footway accommodation.

Copies of specification, including plans, technical information, general conditions, and Tender forms, may be obtained by bona fide tenderers on application to the Under-Secretary for Public Works, Sydney, or to the Agent-General for New South Wales, Australia House, The Strand, London; the Minister of Railways and Canals, Ottawa; the Australian Trade Commissioner in the United States, New York; or the Bureau of Foreign and Domestic Commerce, Washington, D.C., United States.

Tenders, the time for which has been extended, must reach the Under-Secretary for Public Works, Sydney, New South Wales, not later than 30th November, 1923.

R. T. BALL,
2335 Minister for Public Works and Railways.

Administrative County of

LONDON.

COUNTY HALL—ENGINEER-IN-CHARGE.

APPLICATIONS are INVITED by the London County Council for the POSITION of ENGINEER-IN-CHARGE of MACHINERY, &c., at the County Hall, at a salary commencing at £250 a year and rising by six annual increments of £15 and a final increment of £10 to £350 a year.

The foregoing scale of salary is based on pre-war conditions and is at present subject to temporary additions on the Civil Service scale, fluctuating according to the cost of living and making the total commencing remuneration £377 a year. The next revision of the temporary additions will take place not later than 1st September, 1923.

The person appointed to the position will be required to reside in the immediate vicinity of the County Hall, and if at any time quarters are provided for him at the County Hall he will be required to reside in them and to pay such rent therefor as may be fixed by the Council.

Members of the Council's staff are not precluded from submitting applications.

Candidates must not be less than 30 or more than 45 years of age, on the latest date for receiving applications, and unless they served with His Majesty's Armed Forces during the Great War must be natural-born British subjects. Due weight will be given to the claims of those applicants who served, or attempted to serve, with His Majesty's Forces during the war.

Apply for form (containing full details) to the Clerk of the Council, The County Hall, Westminster Bridge, S.E. 1. Stamped addressed foolscap envelope necessary. Forms must be returned not later than 4 p.m. on 4th June, 1923. Canvassing disqualifies.

JAMES BIRD,
2561 Clerk of the London County Council.

Borough of Dover.

ELECTRICITY DEPARTMENT.

APPLICATIONS are INVITED for the POSITION of POWER STATION SUPERINTENDENT in the Electricity Generating Station, to Take Charge of combined Traction and Lighting Machinery and to Supervise the Carrying Out of further Extensions of Plant.

A thorough knowledge of alternating-current working essential, and preference will be given to those having experience in traction plant.

Salary in accordance with N.J.B. Schedule, Class A, Grade 3 (at present £389 17s.).

Applications in writing, with copies of not more than two recent testimonials, to be delivered to the Town Clerk, Brook House, by Noon on Monday, 4th of June.

Canvassing will disqualify.

R. C. HARPUR,
2567 Borough Electrical Engineer

PUBLIC NOTICES

Kent County Mental Hospital,

CHARTHAM, NEAR CANTERBURY.

ENGINEER and CLERK of WORKS REQUIRED. Salary £265 per annum, (no bonus), with house, garden, coal and light, valued at £45 per annum. Age to be under 40 years. Applicants must be thoroughly experienced in all branches of engineering work, must be able to draw plans and carry out the duties of a Clerk of Works as required.

The appointment will be made subject to the Asylums Officers' Superannuation Act, 1909.

Forms of application, to be returned not later than Monday, June 4th, may be obtained by sending a stamped addressed foolscap envelope to the MEDICAL SUPERINTENDENT. 2562

SITUATIONS OPEN

WANTED, ASSISTANT MANAGER by Well-known Gear Makers; must have good all-round knowledge of Machine-cut Gearing and previously held similar position. Age about 35 years.—Address, 2487, The Engineer Office. 2487 A

TO MECHANICAL ENGINEERS.

WANTED, Competent ENGINEER, Capable of dealing with Structural Steel, Cast Iron, Concrete and Brickwork, Taking Out Quantities, Preparing Estimates, Supervision of Drawing-office, and of Construction, but mainly from the office. Strict sobriety and good testimonials absolutely necessary.—Letters, fully stating qualifications, experience, and salary, to "ENGINEER," c/o J. W. Vickers and Co., Ltd., 5, Nicholas-lane, E.C. 4. 2550 A

WANTED in London by Well-known Engineering Firm, First-class COMMERCIAL ENGINEER with Electrical and Hydraulic Training, preferably with connection among municipal engineers in South of England. Also similarly trained MAN accustomed to foreign and export business. Suitable remuneration to experienced men.—Address, with full particulars of education, training, qualifications, and experience, 2557, The Engineer Office. 2557 A

A POST WORTH £5 PER WEEK.—TRAVELLERS REQUIRED, with sound connections amongst Motor and General Engineers, Garages, Ironmongers and Dealers throughout Great Britain to sell a new make of Spring Lock Washer as a side line on 20 per cent. commission basis. Only men of proved selling ability need apply. State exactly in first letter details of experience, ground covered, age, &c.—Address 2498, The Engineer Office. 2498 A

ADVERTISERS Have VACANCY for ENGINEER as REPRESENTATIVE, who can introduce to them good selling specialities, either manufacturing on agencies. Splendid opening for keen man.—Write full particulars, BARRONS, 148, Curtain-road, London, E.C. 2. P7489 A

ENGINEER, to Take Charge of the Design, Building, and Running of a Department of Small Automatic Feed Machines on Sheet Metal and Wire Articles, including control of male and female labour. Applicant must be a sound practical man with experience in working to fine limits and have had technical training in machine and tool design. Good opportunity with an old-established Birmingham firm that is rapidly expanding.—Write, giving full particulars of experience, to Box 1055, Haddon's Advertising Agency, 11, Bennett's-hill, Birmingham. 2536 A

JAMES DUNLOP AND CO., LTD.—The Directors of this Iron, Steel and Coal Company invite APPLICATIONS for the POSITION of GENERAL MANAGER.—Applications, which will be treated as confidential, are to be addressed to the CHAIRMAN, Mr. R. M. DONALDSON, Blairvaddick, Row, Dumbartonshire. P7468 A

MANAGING DIRECTOR for Large Shipbuilding, Engineering and Repairing Yard; good position for experienced man; financial interest not required.—Address, stating experience, 2435, The Engineer Office. 2435 A

RATE FIXER for Switchboard and Cubicle Erection; only first-class men with similar experience considered. State age and salary required.—Address, 2473, The Engineer Office. 2473 A

A VACANCY Occurs in a Leicestershire Engineering Works for a thoroughly experienced JIG and TOOL DESIGNER, preferably a practical Toolmaker, who has had some years' drawing-office experience on thoroughly interchangeable work of medium size. State age, wage, and full details of experience during the last five years.—Address, 2447, The Engineer Office. 2447 A

BLAST-FURNACE DRAUGHTSMAN REQUIRED by large firm of Iron and Steel Manufacturers in the Midlands.—Address, stating experience and salary required, 2585, The Engineer Office. 2585 A

DRAUGHTSMAN, Experienced, REQUIRED.—Fullest particulars, marked "Private," to ERNEST WEST and BEYNON, Ltd., Refrigerating Engineers, 82, Belvedere-road, Lambeth, London, S.E. 1. P7481 A

DRAUGHTSMAN, LEADING, WANTED; Well up in Theory, Design and Practice of Centrifugal Pumps for all purposes. State experience and salary required.—Address, 2481, The Engineer Office. 2481 A

DRAUGHTSMAN REQUIRED, Experienced in the Design of Jigs, Press Tools and Fixtures. Only men with long first-class experience need apply. Appointment would be a temporary one only. Give full particulars of experience, age, and salary required. —Address, 2557, The Engineer Office. 2557 A

DRAUGHTSMAN REQUIRED, with Experience in Aircraft Engine Design. Please state experience and salary required.—BRISTOL AEROPLANE CO., Ltd., Fulton, Bristol. 2548 A

DRAUGHTSMAN REQUIRED, Workshop Experience essential; thoroughly experienced in Pipe Lay-outs, Tank Work, &c.—Address, giving full particulars of experience, also age and salary required, 2552, The Engineer Office. 2552 A

DRAUGHTSMAN WANTED for Cold Storage Designs. State age, experience, and salary required.—Address, P7475, The Engineer Office. P7475 A

DRAUGHTSMAN WANTED for Large Engineering Works in Bombay; age not exceeding 30; single man preferred.—Write, giving full particulars of career, to "DRAUGHTSMAN," c.o. Deacons, Londenhall street E.C 3. 2453 A

DRAUGHTSMAN WANTED, Accustomed to Colliery Screening Plants, Headgears and Structures.—State experience, references, when at liberty and salary to G. R. TURNER, Ltd., Langley Mill, Notts. 2525 A

FIRST-CLASS DRAUGHTSMEN WANTED, Preferably with a knowledge of Lifting, Transporting and Conveying Machinery. State age and salary required.—Address, 2471, The Engineer Office. 2471 A

ONE or TWO Good SENIOR DRAUGHTSMEN REQUIRED. Only men with first-class Aeroplane experience need apply.—Reply, stating age, experience, salary, &c., to A.D.C. Design Department, Waddon. P7484 A

TEMPORARY DRAUGHTSMAN WANTED for the Design of Small Mechanical and Electrical Apparatus.—Address, stating full particulars, 2570, The Engineer Office. 2570 A

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For continuation of Small Advertisements see page 3

New Gasworks at Carlisle.

No. I.

CARLISLE claims to have been one of the first towns in the country to make use of coal gas as an illuminant. The first gasworks were erected in 1820 at a cost of between £5000 and £6000 by a private company, and the undertaking was sold to the Corporation in 1850. The site of the original works had, however, been disposed of to the Lancaster and Carlisle Railway Company in 1846. This involved the erection of a new works by the Corporation, and these works, with numerous extensions, continued to serve the inhabitants of Carlisle until recently.

The great increase in the consumption of gas that has taken place in Carlisle is shown by the following figures:—

Date.	Annual sale in cubic feet.	Number of customers.
1850	40,000,000	1,008
1870	80,071,000	4,790
1890	198,907,000	6,001
1921	432,215,000	12,496

Acting upon the advice of its engineer and manager Mr. J. E. Blundell, the Corporation decided, about three years ago, that in order to keep pace with the increasing demand, a new works would have to be provided, and an installation with a daily capacity of 3,000,000 cubic feet of gas was determined upon.

A fresh site was selected and sanction obtained to borrow £350,000 for the purpose. Erection was commenced in May, 1920, and the new works were completed in September of last year. The site is in Rome-street and covers an area of 5.9 acres. It is shaped—see Fig. 1—like a right-angled triangle with a curved hypotenuse formed by the Carlisle and Maryport Railway, and the two sides by Rome-street and a private road to the Corporation's refuse destructor. The situation of the works is very convenient for fuel supplies. The Mayport and Carlisle Railway system is connected with the main English and Scottish lines. A cross-over road has been constructed to communicate with the gasworks sidings—as shown on the plan, Fig. 1. The sidings have a total length of 990 yards. On entering the works, the sidings diverge into three parallel lines following the inside contour of the curved boundary, and converge again at their furthest point in the works at Rome-street. The inner line is the reception siding, the outer line the despatching siding, and the middle line is a free running loop. It is thus possible for a locomotive to draw its train of coal wagons along the inner reception line, to deliver coal or to receive coke, and to uncouple and retire along the middle line, even when the outer line is occupied by filled wagons waiting despatch. A 60-ton Pooley weighing machine has been provided at the entrance to the sidings. At the Rome-street extremity the lines run into an archway under Rome-street, and this forms the locomotive shed. It has an inspection pit, and is heated by water coils from a coke-fired boiler. A weigh-bridge is also provided at the main entrance for dealing with traffic by road. Mr. Blundell, the engineer, has put down a plant of the most modern type in all particulars, including continuous retorts of the vertical type on the well-known Glover-West system. The contract for the carbonisation plant and the whole of the foundations of the ferro-concrete work was placed in the hands of West's Gas Improvement Company, Limited, Manchester, which has put at our disposal the drawings, photographs, and particulars for the present article.

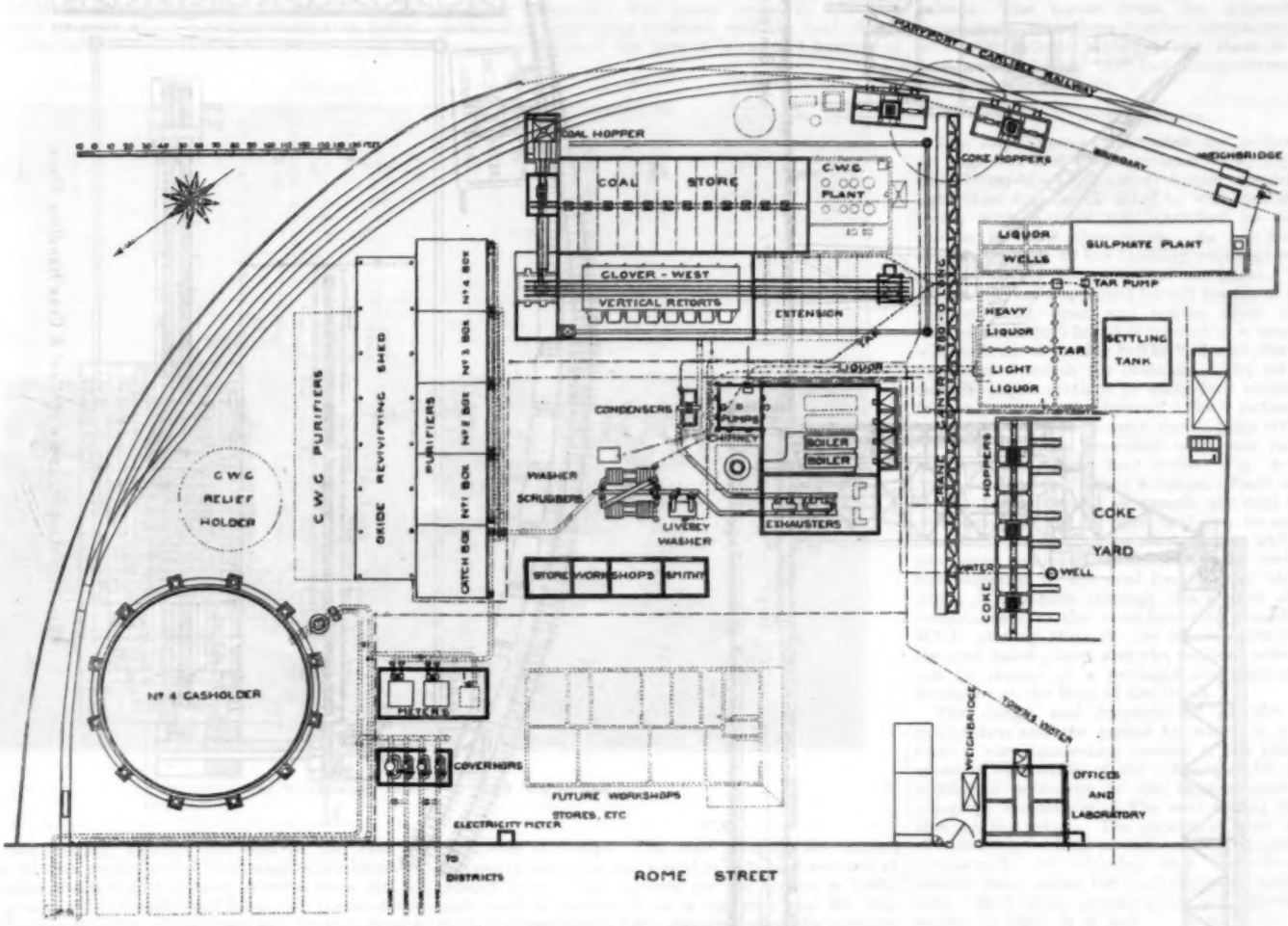


FIG. 1—PLAN OF CARLISLE GASWORKS

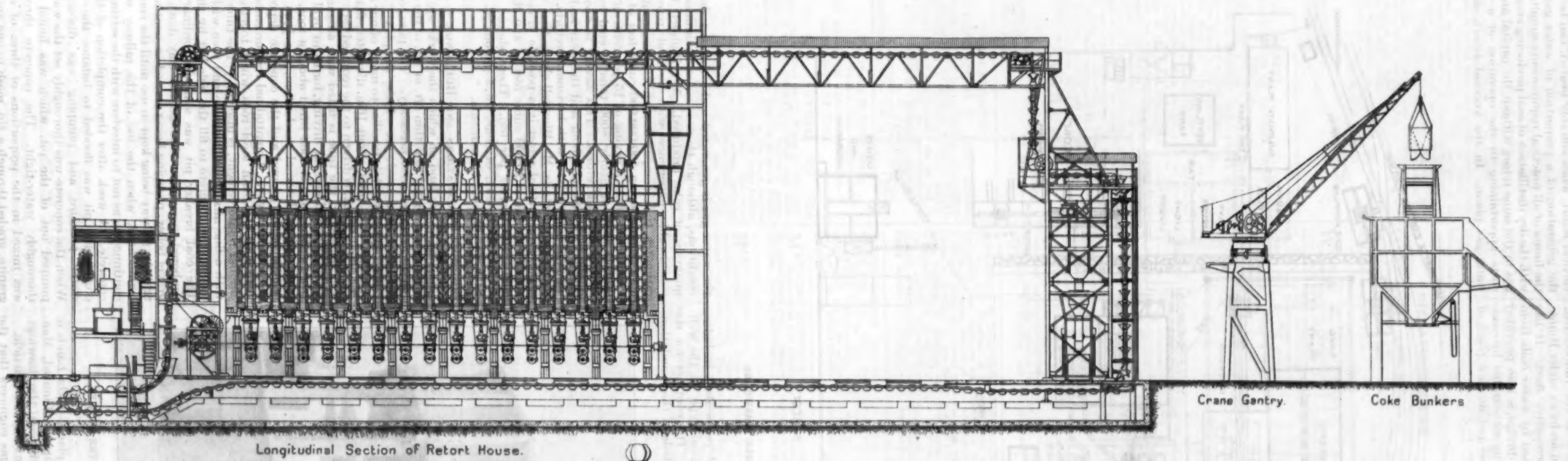
FIG. 2—CONCRETE WATER TOWER

It is generally accepted by gas engineers that the water gas is generated under the best theoretical conditions, although there is some diminution in the quantity of coke produced. Mr. Blundell has had considerable experience with vertical retorts and estimates that compared with the horizontal type a works producing 500,000,000 cubic feet of gas per annum will effect a saving of 15 per cent. in the net cost of coal, or nearly 8000 tons of coal compared with horizontal retorts. This saving is apart from that on the cost of labour and the wear and tear of machinery employed with horizontal retorts. Going further into details, Mr. Blundell claims that with the continuous vertical retort it is possible in every-day practice to make 20,000 cubic feet of 450 B.Th.U.'s gas or 90 therms per ton. There should also be a yield of 10 cwt. of coke, 16.5 gallons of tar and 28 lb. of sulphate of ammonia.

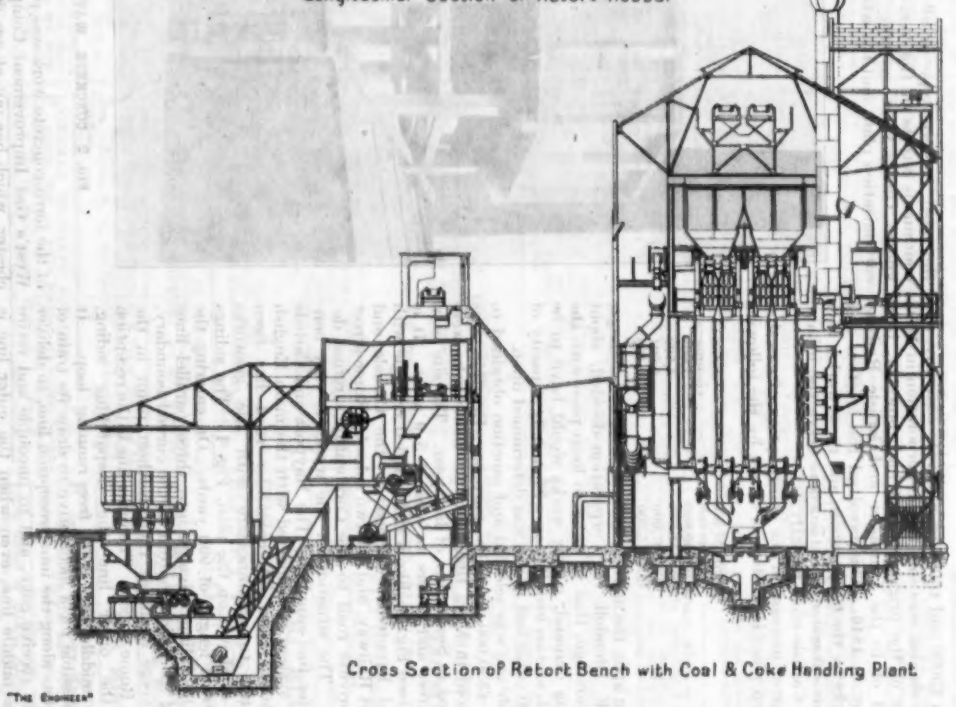
FOUNDATIONS AND BUILDINGS.

Owing to the land on which the works are erected being water-logged to within 6ft. or 8ft. of the surface, pile foundations were necessary. The piles, of which 433 have been used, are of the Simplex "cast-in-place" type, which is familiar to many of our readers. A hollow steel tube, about 16in. diameter, fitted with a cast iron point, is driven to the required set. Where it is necessary, the tube is fitted with alligator jaws which, when closed for driving, forms an oval section point. The tube is then lifted about a foot, and by means of an internal mechanism, the jaws can be opened in the ground and the concrete deposited in the ordinary way. Longitudinal reinforcement, consisting of six plain steel rods wired together with circular reinforcement, is inserted. The tube is filled with a fine mixture of concrete and then withdrawn, leaving the concrete to fill the hole left by the tube. The coal breaker pit was sunk by ordinary close timbered excavation through the clay down to the gravel below, pumping being carried on continuously, and the railway being kept in use until the concreting commenced, when the use of the railway was discontinued so as not to interfere with the setting of the concrete. A week after the completion of the concreting the pit was flooded to balance the external water pressure and pumping was discontinued. When the concrete was thoroughly set the water was pumped out of the pit, which was found to be thoroughly water-tight. The concrete throughout was mixed in the proportions of three of crushed granite, graded through a ¾in. mesh to one and a-half

CARLISLE GASWORKS—THE RETORT HOUSE

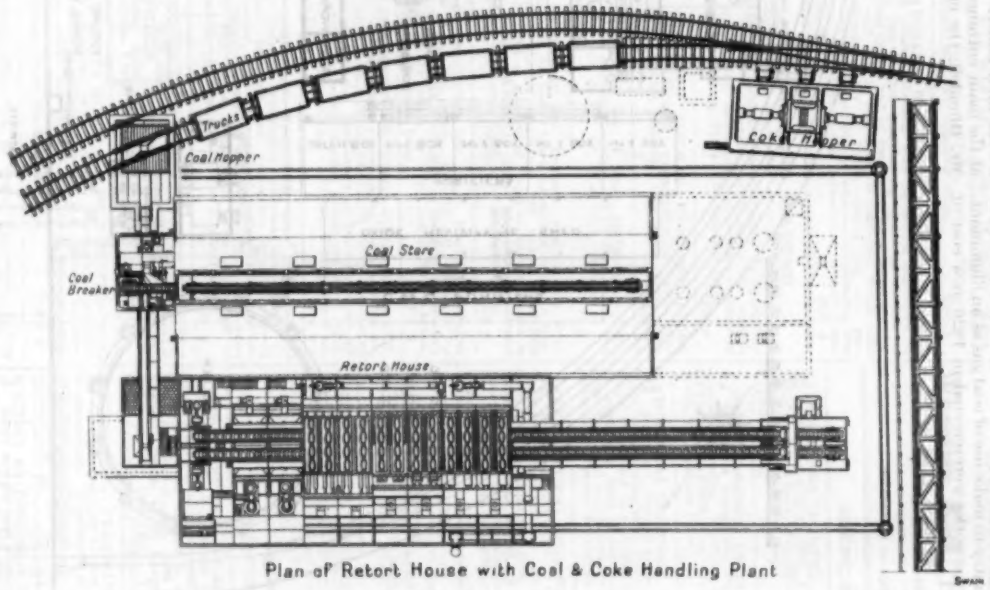


Longitudinal Section of Retort House.



Cross Section of Retort Bench with Coal & Coke Handling Plant

"THE ENGINEER"



Plan of Retort House with Coal & Coke Handling Plant

portions of washed, screened sand, to one portion of cement.

COAL BREAKING AND CONVEYING.

Coal is received in the inner line of the works sidings in hopper-bottom wagons, the contents of which are discharged into a 10-ton receiving hopper supported in the coal breaker pit—shown in the drawings on page 542. A reciprocating tray feeder, with adjustable stroke, placed at the mouth of the

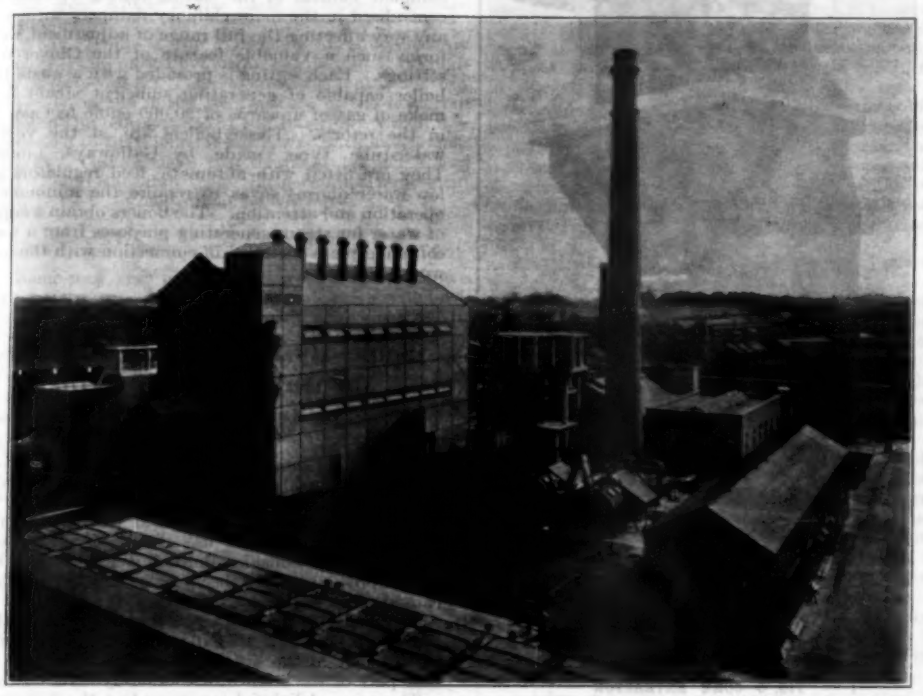


FIG. 3—GENERAL VIEW OF THE GASWORKS

receiving hopper, delivers the coal at the rate of about 50 tons per hour to a West single-claw breaker, by means of which it is reduced to cubes from 4in. to 6in. in size. The broken coal drops into the boot of a fixed bucket elevator, which raises and conveys it to a system of chutes above the secondary breaker, also of the West single-claw type. These chutes are so arranged that the coal may be delivered from the elevator to a gravity bucket conveyor and deposited in the coal store, or it may pass straight to the secondary breaker, by which it is reduced to cubes 1¼in. to 2in. in size suitable for the carbonising plant, or it may be taken from the coal store by the same gravity bucket conveyor and delivered to the secondary breaker. The broken coal is received from the breaker on a flat band 2ft. wide, which elevates and conveys it to an Avery weighing machine arranged at the end of the retort bench, and thence to either of the two lip-bucket conveyors which encircle the retort bench, elevating and storing the coal in overhead bunkers containing forty-eight hours' supply for the retorts.

The coal store—see the lower view on page 552—is of reinforced concrete construction, and holds 4000 tons of coal, or about twenty-one days maximum requirements. It is equipped with a gravity bucket conveyor of 50 tons per hour capacity passing above and below. In one of the drawings on page 542 it will be seen that the top gallery of the coal store carries the gravity bucket conveyor for filling the store. The sloping roof below is fitted with ventilators. The side slopes of the roof are inclined inward to form a large snow gutter on each side, the melted snow being taken away by down pipes at the ends of the building. The whole structure is monolithic and internally braced against the outward pressure of the coal. The side adjacent to the retort-house is arranged to take the steel sub-structure of the retort-house side wall. In the portion of the floor forming the roof of the tunnel are 12 hopper mouths—see page 542—with duplex coal valves, by means of which coal from any part of the store can be admitted to the portable filler of the gravity bucket conveyor. The retort bench foundations consists of a group of piles joined together by a continuous ferro-concrete cap on the producer side, and the loads from the stanchions on the other side are carried upon groups of five piles with a ferro-concrete cap to each group. Running through the whole length of the foundations is the tunnel for the two lines of lip-bucket conveyor which handle the coal and coke from the retort bench. It is built to the full length required for the subsequent extension contemplated on this site. The body of the tunnel is in reinforced concrete, and the roof in the yard is of similar material, strong enough to carry the weight of 12-ton motor lorries, but in the retort-house it is constructed of steel girders and plates specially designed for feeding and giving access to the conveyors. The design of the foundations and reinforced concrete work was carried out by Mr. Burnard Geen, M. Inst. C.E.

The water tower—Fig. 2—consists of a reinforced concrete tank octagonal in plan, capable of containing 50,000 gallons of water at a head of 35ft. above datum. The water is pumped from the river Caldew, and the tank is built with two compartments to facilitate cleaning. The pump house is arranged within the supporting columns, and the roof of the house forms one of the tiers of horizontal bracing of the tower structure. The nine columns are carried on twenty-one piles tied together in both directions at ground level. The chimney for the boilers is 150ft. high, and is supported on a concrete cap 3ft. 6in. thick on twenty-nine ferro-concrete piles, the pressure on the foundations, allowing for wind pressure, being 632 tons.

The crane gantry—illustrated in the drawings on page 542 and in the upper view on page 552—is 280ft. long by 9ft. 8in. wide and 24ft 6in. high from the ground to the crane rail level. It has to carry a 2-ton electric locomotive crane, and provision had to be made for stresses due to the crane's operations while travelling, hoisting and slewing. The crane runs on 56 lb. rails laid on longitudinal timber sleepers attached to the ferro-concrete. Each column of the gantry is supported on a ferro-concrete pile. These piles are tied together in both directions except in the case of four of the columns adjacent to the underground tar and liquor wells, where it was necessary to go down to the solid with mass concrete. The tar and liquor wells consist of an underground tank 60ft. by 63ft. by 12ft. deep, capable of holding 273,000 gallons. They are constructed of ferro-concrete throughout, and are divided into three distinct compartments. The tar and liquor flow together from the retort-house to a Dempster separator, whence the tar flows from the first compartment extending the full length of the spare tank and having a capacity of 93,000 gallons. The liquor from the separator flows successively into three further compartments, each of 90,000 gallons capacity, and there is an overflow passage from the last compartment to the adjacent existing wells.

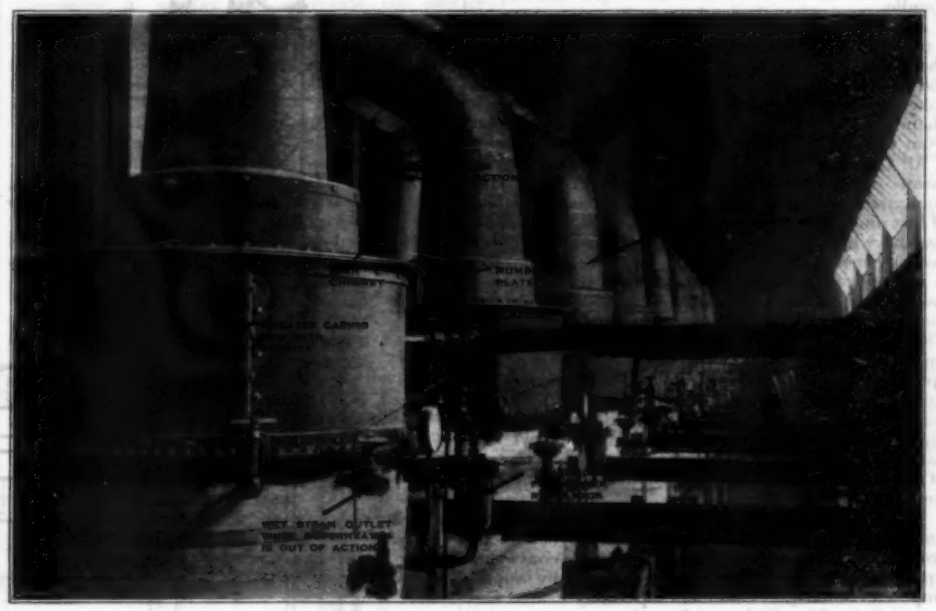


FIG. 4—BATTERY OF WASTE HEAT BOILERS

RETORT-HOUSE.

The retort-house—illustrated by sectional views on page 542 and in the general view, Fig. 3—is of the Glover-West standard design, consisting of a light steel framework filled in with red brick 4½in. thick, with a slate roof attached to steel-angled purlins by aluminium wires. As previously mentioned, the side of the building adjacent to the coal store is carried upon a wall of the latter. The other three sides are supported by sill beams of reinforced concrete 22ft. span and resting upon piles. The floor of the retort-house is formed of a concrete slab, with a finish of paving bricks laid with the necessary falls and channels for drainage. The retort bench contains eight settings or sixty-four vertical retorts for continuous carbonisation. Each setting contains two units of four retorts each—page 542—heated by one producer provided with one independent chimney and waste heat boiler—Fig. 4—all built quite free from adjacent settings. Each retort also forms a separate unit as regards the coal feed, coke discharge and gas off-take, and can be adjusted to the quality of coal under treatment as well as to the gas being produced. The coal to be carbonised is first supplied to the coal feed hopper above, from which it descends through the retorts slowly and continuously to the coke-receiving chamber below. While passing through the retort carbonisation of the coal takes place, and the residual coke is drawn out by means of a mechanically operated helical extractor at the base of the retort.

The design and construction of the extractor mechanism and the means by which it is operated form a very interesting feature of the plant, as the speed of extraction of the coke must be capable of regulation according to the time required for the complete distillation of the coal during its passage through the retort. The apparatus must be capable of operating for long periods without stopping except occasionally for cleaning and inspection of the retorts, when access for such purposes must be available. How these requirements are provided for is shown in Figs. 5, 6 and 7. Briefly, the extractor proper consists of a cast iron helical inclined plane or worm, which revolves slowly within a cylindrical casing below the retort, the angle of the inclined plane corresponding to the angle of repose of the coke. The inclined plane is mounted upon a vertical spindle which passes down through a stuffing-box and is caused to revolve very slowly by means of worm gearing operated by the ratchet and pawl mechanism shown in the illustrations, the speed being regulated by means of a mask. Uniform reciprocating movements are given to the whole of the pawls by means of the driving gear—shown in Fig. 7—which is situated at one end of the retort-house. The driving mechanism of each extractor is totally enclosed in a gear box, which can be removed without disturbing the extractor or any of the retort fittings. The mechanism is provided with an overload release or

safety device, which operates in the event of any obstruction occurring to the revolution of the extractor. From the sectional drawing—Fig. 5—it

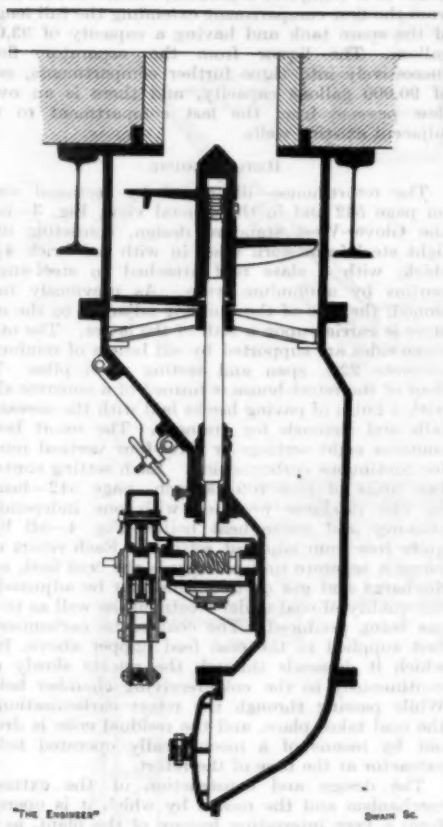


FIG. 5—SECTIONAL VIEW OF COKE EXTRACTOR

will be seen that the extractor helix is made in two halves, the lower half being secured to the vertical shaft and the upper half being loose on the end of the shaft. Although thus divided, the construction is such that the helix is continuous, the top half being driven by the bottom half. This arrangement is necessitated to enable the top section to be partially rotated on the shaft to disclose an aperture, through which and the opening on the side of the coke chamber ample access is provided for the periodical inspection of the retort. Incidentally, it may be mentioned that owing to the great heat to which the top section of the helix is exposed the difficulty of keeping the top section free to revolve on the shaft is overcome by the provision of loose cast iron rings or bushes on the spindle.

As the blade of the extractor is cut away at the top a core of coke lies within the helix, and the action of the extractor is positive, the coke being free to leave the retort when the plane is rotated away from the coke. It is discharged without breakage into a chamber provided with a sealed outlet suspended from the extractor casing.

All the extractors are operated simultaneously by means of the driving gear—shown in Fig. 7. This comprises a steel framework which carries a system of fast and loose pulleys, belt, spur and double helical gearing which gives motion to a reciprocating cross-head by means of a crank. The driving mechanism is in duplicate in case of breakdown, and consists of two totally enclosed ventilated 6 horse-power electric motors, by Electromotors, Limited, Openshaw. These motors run at a speed of 600 revolutions per minute, and by means of the mechanism shown, this speed is reduced to three revolutions of the crank per minute. The horizontal movement of the cross-head or sliding block is about 9in. in each direction, and this movement is communicated to the pawl and ratchet mechanism of the extractor gear by means of an endless system of rods and chains with connecting links and tension blocks.

The coke discharged by the extractors is received and temporarily stored in the receiving chambers, from which it is periodically discharged to a conveying apparatus. The retorts are surrounded by super-imposed combustion chambers separately heated and controlled. The products of combustion make their exit from the upper chambers and circulate round the tops of the retorts, after which they pass away to the chimney. Secondary air supplied for the completion of combustion enters a setting by way of passages formed in the heated walls of the combustion chamber. As the coal passes down the retorts, the heat gradually penetrates towards the centre, the speed of the coke extraction being so regulated that complete carbonisation is effected towards the base where a tapered core of coal is formed. The residual heat of the coke, instead of being wasted and necessitating large volumes of water for quenching purposes, is utilised for superheating the steam admitted at the base of the retort for the generation of water gas. The heat contained in the waste gases from the combustion chambers is applied to the generation of moderately superheated steam in boilers situated at the base of

FIG. 6—COKE EXTRACTOR

the chimney. The steam being supplied to the retorts dry, is there raised in temperature by contact with the outgoing coke to 1800 deg. Fah., at which temperature the water gas reaction is said to be complete.

The combustion zones of the retort are built of silica segmental blocks, while the top and bottom sections are made of hard fire-clay segments. The retorts are elliptical in section and of ample strength to stand alone in the setting with freedom from distortion due to expansion and contraction. The silica blocks are made by the Derbyshire Silica Firebrick Company. They are tested at 1750 deg. Cent., Seger cone 34, and show an expansion at combustion chamber temperatures of less than one-quarter of 1 per cent. The producers for supplying the retorts with gas are of the open step-grate type, and the complete control of the setting during operation is centralised in the main chimney dampers without in any way affecting the full range of adjustment which forms such a valuable feature of the Glover-West settings. Each setting is provided with a waste heat boiler capable of generating sufficient steam for a make of gas of upwards of 20,000 cubic feet per ton in the retorts. These boilers are of the vertical water-tube type, made by Galloways, Limited. They are fitted with automatic feed regulators and low-water alarms so as to require the minimum of operation and attention. The boilers obtain a supply of water for steam generating purposes from a water softening plant installed in connection with the main works boilers.

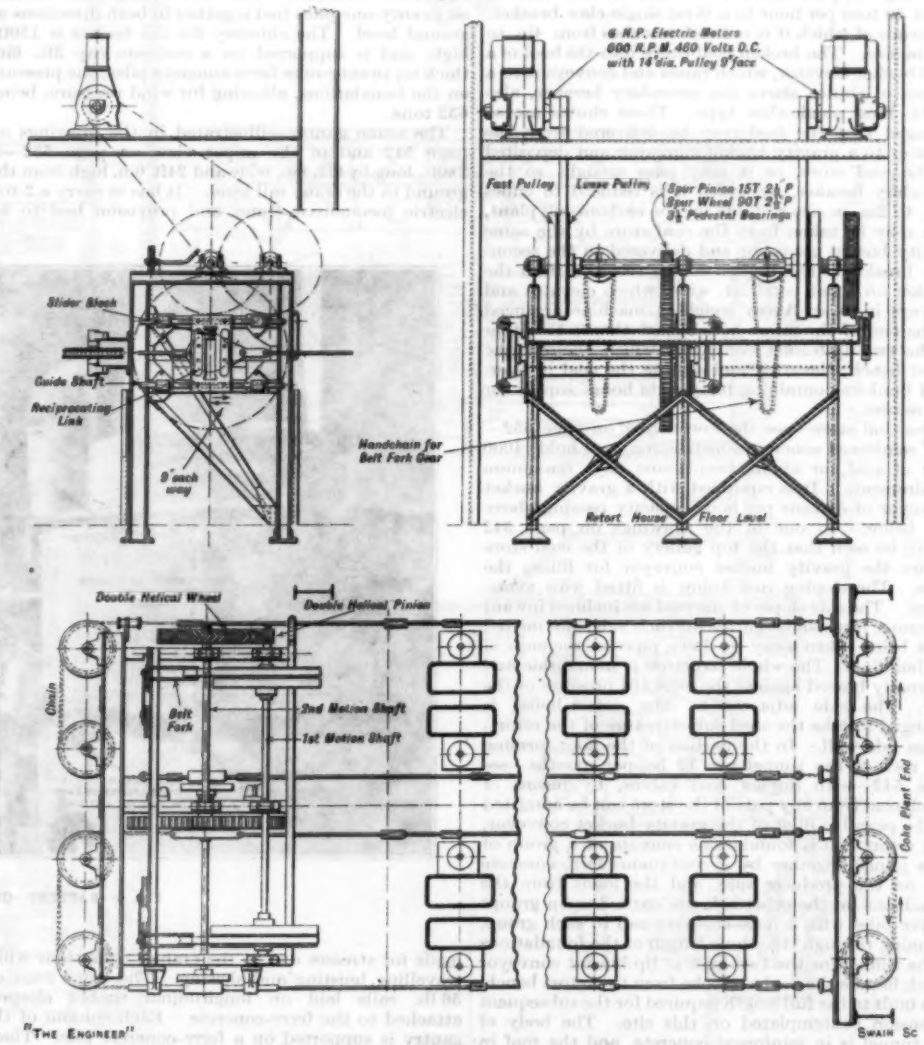


FIG. 7—MECHANISM FOR OPERATING COKE EXTRACTORS

Some By-Paths in the Fundamentals of Engineering.

By JULIUS FRITH, M.Sc., and FREDERICK BUCKINGHAM, B.Sc.

Is it not curious that all these years the text-books have been speaking of the "mechanical equivalent of heat" when they mean, and Joule meant, the thermal equivalent of mechanical work? We take it that the text-books use the former expression from euphonic considerations, but we suppose that few expressions have been so misleading or have caused more confusion in the minds of students.

At first blush the two terms may seem much alike, but we do not think that it is putting it too strongly to say that in the difference between them lies the best part of the science of thermo-dynamics.

There is a delightful law regarding the "degradation of energy," which, whilst allowing all other energy to be converted to heat at 100 per cent. efficiency, decrees that only a portion, generally quite a small portion, of the energy of heat can be converted to mechanical energy or work.

So that the expression "thermal equivalent of

mechanical work" has a very definite meaning, and if Joule stated that 1 B.Th.U. resulted from the conversion of 778 foot-pounds of mechanical work into heat, he stated a universal fact that can be verified in a dozen different ways and under a hundred different conditions; but when, on the other hand, the text-books state that 778 foot-pounds are the equivalent of 1 B.Th.U., they state a terminological inexactitude which is enough to make Joule turn in his grave.

Joule showed one side of the picture, which was at the time a tremendous advance in knowledge, but which is now a mere truism; but Carnot showed the other side, which is the basis of modern thermo-dynamics.

What, then, *is* the "mechanical equivalent of heat"? The most obvious answer is that it depends on its *temperature*. The real answer is that it not only depends on the initial temperature of the heat, but also on the temperature of the sink down which it is proposed to tip it when it has parted with its *available* energy. Calling these two temperatures big T and little *t* on the absolute scale, the mechanical equivalent of 1 B.Th.U. of heat might be written—

$$778 \times \frac{T - t}{T} \text{ foot-pounds.}$$

Some may very likely say, "Well, we have known all that from our cradles!" We might, in reply, ask why, then, they talked of Joule's equivalent as the "mechanical equivalent of heat." But we say more; they did not *know* it. They may have given it their "mechanical" assent, but if they had *known* it, they would not have spoken of the efficiency of a boiler as, say, 75 per cent. What was that boiler? Was it a part of a *power* plant, or was it an apparatus to make warm water? If it was the latter they may be excused; but if the former, then how do they account for the fact that the boiler received heat at, say, 2500 deg. Fah. absolute and gave 75 per cent. of it out at a temperature of only 1000 deg.? Taking 90 deg. Fah. (550 deg. absolute) as the temperature of the sink (condenser), the boiler has, for every B.Th.U. fed in with the coal received, the equivalent of $778 \times \frac{2500 - 550}{2500} = 600$ foot-pounds, but only gives out the equivalent of $.75 \times 778 \times \frac{1000 - 550}{1000}$ = 260 foot-pounds, and therefore its efficiency as a member of a power plant is only $\frac{260}{600}$, or 43 per cent.

Judged by the same standards, the engine is not nearly so bad as it is generally painted; it is obliged to reject all heat when it falls to 550 deg. absolute, as below this temperature it cannot get rid of it. Working between the limits of temperature stated above of 1000 and 500, a good modern engine can do 150 foot-pounds of mechanical work for each B.Th.U. supplied to it in steam, which is an efficiency of

$$\frac{150}{778 \times \frac{1000 - 550}{1000}}$$

or 43 per cent., exactly the same as the boiler above.

With a little practice it soon becomes natural to work out efficiencies in this way, and we wonder at anyone ever expressing the efficiency of any part of a power plant as B.Th.U. got out divided by those put in, irrespective of their temperature, which is the only measure of their usefulness for the purpose in hand. One might just as well express the efficiency of a water turbine as gallons got out over gallons put in, or the efficiency of a motor generator as output in Coulombs over input in Coulombs, irrespective of the voltage. For electro-plating work this might be useful, as might the thermal efficiency of a boiler installed for bath water.

We believe that the fuzzy thinking indulged in on this topic by most engineers is entirely due to the error involved by the expression "mechanical equivalent of heat," with its implied erroneous idea that 1 B.Th.U. and 778 foot-pounds are interchangeable quantities *either way*.

Most engineers with whom we have discussed this seem to be convinced that energy can be expressed in B.Th.U., and that therefore 1 B.Th.U. is as good as another. One such engineer, when partially convinced of the truth, wished to smash Joule's statue in the Manchester Town Hall with a hammer. But the fault does not lie with Joule, but with the text-books and teachers who carelessly use Joule's equivalent as if these conversions were reversible; they are no more reversible than is the process of killing cats. Merely as a quantity of material a dead cat may be as effective as a live cat, but from the view point of an engineer there is just as much difference between a B.Th.U. at 1000 deg. Fah. and one at 60 deg. Fah. as between a live and a dead cat.

It is just here that electrically made heat has its field. Heat made from the burning of fuel is necessarily comparatively low-temperature heat. The limiting temperature can easily be estimated by the Le Chatelier method. For instance, if we use 20 lb. of air to burn 1 lb. of coal of 12,000 B.Th.U. we cannot expect a temperature over $\frac{12{,}000}{21 \times .24}$, or 2400 deg. Fah.

But with electrical energy 1 kilowatt will make heat at 57 B.Th.U. per minute, and these can be made in a place uncooled by air for combustion and not robbed of heat by a flue, so that the temperature can be made to rise indefinitely, only limited, in fact, by our command of refractories.

It is important to observe that both fuel and electrical energy make heat in definite quantities irrespective of its temperature. It is only, of course, when it is a case of making the heat back into a higher form of energy that the question of temperature is so important.

There is a very close analogy with water which may be helpful to some. If water is only required for washing one's hands, the head at which it is does not greatly matter; but if it is for power purposes the energy it has is due to gravity and is proportional to its distance from the centre of the earth, which might be referred to as its absolute zero. This total fall, however, cannot be utilised, as the surface of the earth intervenes, and indeed the water has to be rejected a little above the free level in order that it may expeditiously be got rid of. If we represent the distance from the centre of the earth of the upper water and of the sea level as big H and little *h* respectively, the proportion of the total energy which is available is $\frac{H - h}{H}$. If we tried to get a little more working head by digging a hole to run the tail water into we should find that the water had to be pumped up out of this hole in just such a way as the condensed steam has to be pumped out of the condenser.

The analogy, however, breaks down, as analogies have a way of doing, just when it is most wanted, as there is nothing irreversible about the water power plant.

There is, however, one other point of resemblance which can usefully be worked up. Suppose the water turbine plant to be situated on the sea shore and be fed from a fresh-water spring in the mountains. A town grows up round the power-house, the inhabitants of which have to fetch their fresh water with difficulty from afar. The engineers, in order to get the maximum possible fall, put the draught pipe from their turbine under the sea, and it takes a genius to suggest that the engineers sacrifice a few feet head and allow the tail water to circulate to the inhabitants who are willing and anxious to pay for it.

Yet few engineers of steam power plants are willing to sacrifice an inch or two of vacuum in order to supply their neighbours with the low-temperature heat which to them is waste, but which would be a godsend to thousands of householders.

It appears from what has gone before that if heat is to be made from fuel it is just as expensive to make it at a low temperature as at any other, and therefore it would seem a wasteful idea to burn fuel to make the comparatively low-temperature heat which we require, amongst other things, for the warming of our buildings.

There is in the universe a practically inexhaustible supply of heat at temperatures of from 30 deg. to 60 deg. Fah., which it might be possible to raise the few degrees of temperature necessary for a less cost than to make heat specially.

One possible method of doing this was suggested by Maxwell, by employing demons of molecular dimensions to waylay and segregate the swifter moving particles. For the moment, however, we do not seem to be able to establish contact with said demons, so fall back on Kelvin's suggestion to raise the temperature of this heat by doing mechanical work on it.

We are familiar with a heat engine as one which, taking an enormous quantity of heat, gives out a very little mechanical work. When taken to task about it, the usual and correct reply is that the process is reversible and therefore perfect. Kelvin said in effect, "Granted. Get busy therefore on the reversed cycle, take a small quantity of mechanical work and raise enormous quantities of heat through the desired temperature range."

One way to do this would be to draw in air from outside and compress it, doing mechanical work on it and receiving heat in return; then to expand the air back to its original pressure in an air engine, recovering all, or nearly all, the work expended on it in compression.

Let us take this in easy stages and first look into the case where heat is required merely to be moved from one place to another without change of temperature. Start with a receiver full of compressed air at the specified temperature; from this operate an air engine with gilled cylinders in which the air will do mechanical work and, expanding isothermally, will take up heat. Use this air engine to drive a compressor, also with gilled cylinders, which will take the air from the engine and compress it isothermally, giving out heat and replenishing the receiver with compressed air.

If we assume (1) that heat can flow perfectly freely in and out of the gilled cylinders, and (2) that both air engine and compressor have efficiencies of 100 per cent., then the whole apparatus will be self-supporting, the compressor supplying the compressed air for the air engine, which in its turn supplies the power to drive the compressor. Heat will be absorbed by the air engine and given out by the compressor and the combination can be used like a garden squirt, to suck up heat from one place and eject it at another.

Each pound of air compressed from a pressure P_1 to P_2 (both in absolute measure and any units you like, as only the ratio of the two is used), the process being carried on at a temperature T Fah. absolute, will absorb $124 \times T$ (log. P_2 − log. P_1) foot-pounds of mechanical work, all of which is given out as heat on Joule's correct ratio and so liberates

$$\frac{124\ T\ (\log.\ P_2 - \log.\ P_1)}{778} \text{ B.Th.U.}$$

When the same quantity of air expands from P_2 to P_1 exactly similar quantities of heat are absorbed and of mechanical work are given out.

The above expression will give the size of compressor and engine required to move heat about at any required rate.

If the machines are not perfectly efficient, then auxiliary energy to make up the losses can be supplied by, say, an electric motor coupled to the engine and compressor shafts.

It may be noted that the losses in both air engine and compressor will appear as heat (in Joule's ratio). This will have no effect on the net quantity of heat delivered by the compressor when supplied with the original amount of mechanical work, but will lessen the net quantity of heat absorbed by the engine.

So much for the transference of heat at constant temperature. In general, however, the problem will involve the lifting up of heat from a lower to a higher temperature. Let us call these T_1 and T_2 respectively (still on the Fahrenheit absolute scale). The air drawn in from outside at a pressure P_1 can be raised from T_1 to T_2 by adiabatic compression in a thermally insulated cylinder to a pressure P_2, such that $P_2 = P_1 \times \left(\frac{T_2}{T_1}\right)^{3.45}$. Each pound of air during this preliminary compression will require $184\ (T_2 - T_1)$ foot-pounds of mechanical work expended on it. Once at a temperature T_2, heat can be produced at this temperature in any desired quantity by isothermal compression to, say, P_3 in a gilled cylinder exactly as in the first case dealt with, when each pound of air will absorb $124 \times T_2 \times (\log.\ P_3 - \log.\ P_2)$ foot-pounds and give out this divided by 778 B.Th.U. at the temperature T_2.

After this the air can be cooled back to T_1 adiabatically in an air engine with insulated cylinders, when it will give out $184\ (T_2 - T_1)$ foot-pounds and fall to a pressure P_4, which will, however, be still above P_1.

The final operation is performed isothermally in an air engine with a gilled cylinder, the air expanding down to the original pressure P_1. In this process $124 \times T_1 \times (\log.\ P_4 - \log.\ P_1)$ foot-pounds are given out and $\frac{124 \times T_1\ (\log.\ P_4 - \log.\ P_1)}{778}$ B.Th.U. are absorbed.

The work done and given out in and by the insulated cylinders is equal and so balances out. The ratio $P_3 : P_2$ is equal to $P_4 : P_1$. So that the net work expended $= 124 \log. \frac{P_3}{P_2} (T_2 - T_1)$ foot-pounds.

The heat delivered at a temperature $T_2 = \frac{124}{778} T_2 \log. \frac{P_3}{P_2}$ B.Th.U. Hence the efficiency of the process, expressed in B.Th.U. of heat delivered per net foot-pound of mechanical work expended

$$= \frac{\frac{124}{778} T_2 \log. \frac{P_3}{P_2}}{124 \log. \frac{P_3}{P_2} (T_2 - T_1)} = \frac{T_2}{778\ (T_2 - T_1)}$$

If the mechanical energy expended were turned directly into heat, as, say, in a dynamo and an electric radiator, then the B.Th.U. delivered per foot-pound expended would be $\frac{1}{778}$. So that the advantage of the heat pump process over the direct electric heating

$$= \frac{\frac{T_2}{778\ (T_2 - T_1)}}{\frac{1}{778}} = \frac{T_2}{T_2 - T_1}$$

which, as you might expect, is the Carnot efficiency expression inverted.

For example, if $T_1 = 30$ deg. Fah. and $T_2 = 200$ deg. Fah. the B.Th.U. moved up in temperature from T_1 to T_2 per net foot-pound of mechanical work expended would

$$= \frac{660}{778\ (660 - 490)} = .005$$

and the advantage over direct electric heating would

$$= \frac{660}{170} = 3.9 \text{ to } 1$$

or if $T_1 = 50$ deg. Fah. and $T_2 = 60$ deg. Fah., the B.Th.U. moved per foot-pound

$$= \frac{520}{778\ (520 - 50)} = .066$$

and the "advantage"

$$= \frac{520}{10} = 52 \text{ to } 1.$$

The question of obtaining energy from compressed air does not seem to be always quite clear.

Take equal amounts of mechanical energy and use them for:—

(1) Compressing a spring.

(2) Turning round a wheel with a brake on it.
(3) Compressing air.

In the first case no heat is evolved and the spring will return all, or very nearly all, the energy put into it in the same form, *i.e.*, as mechanical energy.

In the second case heat will be evolved, 1 B.Th.U. for every 778 foot-pounds of work expended, exactly in Joule's ratio.

In the third case, the compressing of air, the whole of the mechanical energy is returned as heat in Joule's ratio exactly as in the last case, and after the compressed air has cooled to its original temperature we are left with a quantity of cool compressed air. This air has no more energy in it than it had before it was compressed; all the energy put into it has been given back as heat. As far as a balance of energy goes the process is as finished and complete as case (2); a given amount of mechanical energy has been expended and its exact equivalent been received in heat.

But you will say, where, then, does the energy in the compressed air come from; it undoubtedly has the power of doing work which the wheel with the brake on it has not? The answer is again as clear as possible. The air has no more energy in it than it had before it was compressed. (The expression for the internal energy of a gas only takes its temperature into account, not its pressure.)

But it had a great deal of energy in it, due to its temperature, before it was compressed, and it is some of this energy which has now become available, and can be obtained in two slightly different ways, which, however, come to the same thing in the end. First, the air can be expanded adiabatically down to atmospheric pressure, in which case its temperature will fall and mechanical energy would be given out proportional to this fall, 778 foot-pounds for each B.Th.U. lost by the air. The very cold expanded air would then be exhausted to atmosphere to be warmed up again, thereby lowering to that extent the average temperature of the universe.

The other possible method would be to expand the air isothermally, when the universe would have to supply and pour into the cylinder the exact equivalent in heat for each foot-pound of work done.

The net result of both these operations is the same, *i.e.*, that the energy which we thought was to be obtained from the compressed air is really obtained from, and at the expense of, the universe, like getting roads made by the unemployed. So that the compressed air is *not* really a source of energy at all, but only a draft on the bank of the universe.

Take the analogy of the sea. All the water in it has energy, due to the attraction of the earth, but this energy is not available owing to the presence of the other water. If by some magic we could annihilate a mass of water deep down in the sea, the water above would be able to fall and do mechanical work, the whole sea level being correspondingly lowered. If water were compressible we might compress the water and so make a hole for the water above to fall into. This is virtually what we have done with the compressed air.

If, for instance, instead of using a 1 kilowatt electric radiator for a source of heat we were to use a 1 horse-power motor driving an air compressor, we should get just as much heat, and, in addition, thrown in, as it were, for nothing, we should have a supply of compressed air which could drive an engine and do odd jobs or could work a dynamo to repeat the process.

A given weight of air at a given temperature has a certain amount of energy irrespective of its pressure; but if it is at a high pressure, that fact enables us to obtain a lower temperature than that of the atmosphere and so allows some of the atmospheric heat to fall in temperature and do work.

It appears to the casual observer that the compressed air let into the cylinder of an engine pushes the piston out and so turns the crank shaft round, and that this purely mechanical explanation fully describes what takes place. In reality this is only a very partial and misleading explanation. For if the engine were not situated in a great ocean of heat which can continually flow into the cylinders as the air in them expands, does work and cools, the engine would get colder and colder until, when all the heat contained in the material of the cylinders, &c., was used up, the whole plant would freeze up solid and stop working. This is so far recognised that air engines are worked non-expansively in the cylinders, the air being allowed to expand and cool outside the engine, receiving heat again from the surroundings.

It is thus seen that the analogy between compressing a spring and compressing air is wholly false and only leads to misconception and wrong thinking.

An aeroplane was brought into use in a recent survey of a projected transmission line from the McCall's Ferry power plant of the Pennsylvania Water and Power Company at Holtwood, Pa., to Coatesville, Pa. The aeroplane flew in a bee line at a height of two miles and a photograph was taken every few seconds. After the flight was completed and the pictures had been developed they were pieced together and an absolutely bird's-eye map of the route, showing a strip 5 miles wide and about 30 miles long, resulted. A great saving in time and effort was thus accomplished.

Iron and Steel Institute.

No. II.*

At the afternoon session on May 10th a long discussion took place on the paper by Professor H. C. H. Carpenter, entitled "The Production of Single Metallic Crystals and Some of Their Properties," which is printed in abstract on another page.

Opening the discussion, Dr. C. H. Desch said he thought that the extraordinarily interesting work upon which Miss Elam and Professor Carpenter had been engaged for some time past indicated the possibility of determining what were the real mechanical properties of metals. It was known that in any ordinary mass of metals the properties must be due in part to the properties of the crystal grains and in part to the properties of the boundary. It had hitherto been impossible to separate those two factors from one another. Definite measurements had now been made of certain mechanical properties of the crystals, and he understood from the author that, before long, measurements of other mechanical properties would be available. It might perhaps be of some interest to refer to work which had been done on other metals, which seemed to throw some light on the process of slipping and deformation generally. In Germany, Polanyi had succeeded in making test pieces of single crystals, not as large as those described by Dr. Carpenter, but in a cast condition and without having to apply cold work and annealing. Polanyi had made a series of measurements with certain metals, particularly tin, lead and zinc, and, in a few cases, aluminium. The results obtained with zinc might be worth mentioning. Zinc, as it was known in the cast condition, was a brittle metal, and a test piece of the cast metal gave only a small elongation. But if a single crystal rod of zinc was prepared it would under certain conditions give an elongation up to six times its length, and at a temperature of 200 deg. Cent. gave an even larger elongation figure. Polanyi's experiments had been checked all through by the X-ray method, and it seemed that the orientation was preserved. His work was later in date than that of Miss Elam and Professor Carpenter, who opened up the wonderfully interesting field under discussion, but he started it quite independently of them.

Dr. W. H. Hatfield expressed the view that this paper was one of the most fundamental contributions that had been made to metallurgy for many years. It was fair to reason by analogy that if the physical characteristics of single crystals in aluminium bore a certain relationship to the physical characteristics of the conglomerate somewhat the same relationship existed in connection with iron, a metal which, unfortunately, the author had not yet been able to tackle. It was relatively easy in considering the properties of metals, iron in particular, to postulate that there was an under-cooled liquid film of indeterminate thickness and composition between the crystals. By so doing it was possible to arrive at any deductions desired. Personally, he thought that they were brought into the realm of fact by this paper, and by a careful consideration of the data which the author had placed before them he felt that after all the material which constituted the crystal of a metal was that which concerned them most in considering the mechanical and physical properties of that metal.

Mr. E. H. Saniter said that Dr. Carpenter's paper was one of extreme interest, and the possibilities of applying a similar method to iron interested him greatly. In drawing hard steel wire it was customary to do what was called "patenting," which was the heating of the wire up to about 1000 deg. Cent. The effect of that process was to destroy the fine crystallisation and to make it coarse. The present paper suggested to him that it might be possible to produce these large grains by a low temperature instead of a high temperature treatment.

Professor Edwards regarded the work described in the paper as not only of fundamental, but of actual practical importance. He would like to emphasise that aspect of the investigation. Under certain conditions in the manufacture of tin-plate steel, particularly where it was necessary for the plates to be subsequently deep stamped, the conditions of manufacture were such that phenomenally large crystals were produced, something like half an inch across. When those crystals, which were very largely confined to the surface of the plate, were subjected to the stamping treatment they gave well-defined corrugations in the article similar to those illustrated in the test piece provided by Professor Carpenter. As a result he had taken up the study of the conditions under which that particular kind of crystallisation occurred in practice. It had been found possible to reproduce the crystals and get the corrugations synthetically, and only last week iron crystals from 2in. to 3in. in length had been obtained. There were, of course, difficulties in the creation of the crystals, but with mild steel which had been specially treated by the removal of the carbon it could be done. That fact had an important bearing on the commercial aspect of the problem.

Miss Elam expressed interest in Dr. Edwards' crystals. She had been trying some experiments in that direction, but had had great difficulty in getting suitable materials. She had, however, succeeded in obtaining some very nice crystals, not so large as Professor Edwards' crystals, because they were in very crude iron, but she hoped that with better materials she might succeed in getting better results. With regard to iron, she would point out that it was useless, if large iron crystals were wanted, to heat below 900 deg. Cent.

At the conclusion of the discussion Professor Carpenter said he would make his main reply in writing, and would confine his oral statement to one or two points. He was very glad that Dr. Hatfield had emphasised the fact that with the experimental material now available they could say that metallic crystals had definite properties apart from any hypothetical material. That was to the author the great interest and value of the work. It had brought from the realm of hypothesis into the realm of fact a certain, if limited, range of facts. Moreover, these single crystals seemed to him to possess the essential properties of metals. Although they did not say so in the paper, the crystals possessed in their limit of proportionality the same properties as metals. The results on this branch of the subject would be published in another paper.

Dr. J. O. Arnold then read a paper entitled "The Correlation of the Chemical Constitutions of 'True Steels' with Their Micrographic Structures."

TRUE STEELS.

True steels may be defined as "saturated steels"—that is to say, steels containing neither structurally free iron nor structurally free metallic carbides.

True iron steel consists entirely of allotrimorphic crystals of the compound micro-constitutent "iron pearlite," discovered by the late Dr. H. C. Sorby, F.R.S., about 1863. True or saturated iron steel may be conveniently here defined thirdly as a "dyad steel," since it contains only the two elements iron and carbon. Concerning this true steel—and, indeed, the other three true steels about to be described—it may be truly said, as the blood is the life, so is the carbon the steel.

True vanadium steel may be chemically distinguished from true iron steel—which is a dyad substance containing only iron and carbon—as a *triad* steel, consisting of iron, vanadium and carbon. In true tungsten steel there is a displacement point of all Fe_3C when the tungsten reaches a little above 11 per cent. and the carbide (WC) is formed. If a little less than 0.75 per cent. of carbon is present, it is entirely appropriated by the tungsten.

The critical displacement point for the ferro-molybdenum true steel is at about 18.2 per cent. of molybdenum with, say, about 0.75 per cent. of carbon. Near these critical chemical points Fe_3C vanishes, being entirely replaced by a most remarkable ferro-molybdenum double carbide true steel, which persists up to at least 21 per cent. of molybdenum. Chromium, cobalt, manganese and nickel fail to form "true steels."

Sir Robert Hadfield, in opening the discussion, said the author had referred to the peculiar properties of the alloys of iron and manganese in connection with brittleness. It was quite true that a slight difference in the carbon content had a considerable effect. They had, however, no commercial use for an alloy of that character, and it could be claimed that manganese steel held its own through its extraordinary quality of hardness. Other points raised in the paper were of considerable importance, particularly the reference to corrosion. Dr. Arnold had reminded them—and perhaps Dr. Hatfield would express an opinion on that point—that after the chromium got beyond 14 per cent. the rate of corrosion tended rapidly to diminish. That was a very important fact, as showing that they ought to make a study of these materials.

Dr. W. H. Hatfield said that in 4.75 vanadium steel the whole of the carbon was in combination with the vanadium, giving vanadium carbide and iron. It was necessary to go to a temperature of about 1400 deg. Cent. before the carbide went into solution. He took exception to the statement that during the last few years the 14 per cent. chromium steel had become familiar as stainless steel. The alloys made in the years 1910, 1911 and later were of ferro-chromium of a necessarily high carbon content. The 14 per cent. chromium steel with which Dr. Arnold and Sir Robert Hadfield had experimented had such a high carbon content that it was not stainless, and the exact composition required was not determined until a later period.

Dr. Thompson, referring to work which he had carried out on the etching properties of the same series of steel as were used in Dr. Arnold's work, was able to state, particularly in connection with the tungsten and cobalt series, that they fully confirmed Dr. Arnold's conclusions. In the tungsten series it was possible by etching tests to determine every one of the constituents discovered by the author. That gave good ground for the acceptance of the other conclusions stated in the paper.

Colonel N. T. Belaiew said an extremely important point in the researches was that the data had been obtained by strictly correlative researches and chemical micrographic methods. It was a point which was sometimes overlooked.

Dr. Arnold, in reply, expressed his thanks for the reception given to his paper and the discussion it had evoked, and intimated his intention to reply fully by correspondence.

A paper by Messrs. J. H. Whiteley and A. Braithwaite, "Some Observations on the Effect of Small Quantities of Tin in Steel," was presented, but it was decided that the discussion should be by correspondence. A short abstract of the paper is as follows:—

TIN IN STEEL.

In this paper experimental evidence is advanced to show that the presence of small percentages of tin in medium carbon steel is liable seriously to impair its ductility, so that in rails even 0.06 per cent. may be unsafe. The harmful effect of tin apparently increases with the carbon content, for in mild steel

* No. I. appeared May 18th.

the above-named amount has, apparently, no detrimental effect. The degree of brittleness produced by tin appears to be influenced also by the heat treatment given; it may be remarked that several observations have been made which suggest that, in investigating the effect of tin, factors such as the finishing temperature and the amount of work applied to the metal in rolling or forging must not be overlooked.

The meeting then adjourned until the following day.

There was a fairly good attendance of members when the meeting was resumed on Friday, May 11th.

CARNEGIE FUND GRANTS.

The Secretary announced that the following grants had been made:—

Cecil Handford (University College, Cardiff), £100, to carry out research on the behaviour of metals within and at the limits of the elastic range.

C. W. H. Holmes (Birtley, Durham), £100, to conduct investigations on the macrostructure of cast iron.

W. R. D. Jones (University College, Cardiff), £100, to continue his work on the silica materials of South Wales, with special reference to the influence of texture.

F. S. Merrils (Musselburgh), £100, to study the fatigue of metals.

E. L. Reed (Harvard University, U.S.A.), £100, for investigation on the structure and physical properties of iron carbon alloys melted and heat treated in vacuo.

The following had received further grants of £50:—

A. L. Curtis (Chatteris, near Cambridge), to continue research on steel moulding sands and their behaviour under high temperatures.

A. M. Parkin (The University, Sheffield), to continue research on the influence of heat treatment and of variable carbon content upon a magnet steel with a constant tungsten composition.

J. H. Whiteley (Stockton-on-Tees) and A. F. Hallimond (Geological Survey, London), a joint grant to enable them to continue their researches on the nature of pearlite.

A paper entitled "The Economic Principles Governing the Use of Electrical Power in Iron and Steel Works," by Mr. C. A. Ablett, was then read. Some extracts from it follow.

ELECTRICITY IN STEEL WORKS.

The governing consideration affecting the installation of plant in a steel works, as in many other works, is the return on the capital expended, and this principle applies as much to power plants as to engines or motors driving mills, or to the mills themselves. This paper is principally concerned with the selection of power plant, and presupposes that the directors' policy has already been decided in so far as the products of the works are concerned.

Experience has proved that the load factor of an iron or steel works can easily be between 60 and 70 per cent., and in some cases even higher, and as the importance of load factor is realised means can often be devised for improving it. On these figures an iron or steel works produces about three times as many units of power from their plant as a public supply authority would, and consequently the capital charge per unit of power produced would, in the case of an iron or steel works, be about one-third that in the case of a public supply authority.

When considering the use of blast-furnace or coke-oven gas as a possible source of electric power, full consideration must be given to the fact that it is more economical to use these gases for heating furnaces than as a source of power, and therefore the gases should be used for heating to the fullest possible extent, and the residue left over, after all heating requirements have been fulfilled, should then be used for the production of power.

An exhaust steam turbine tends to perpetuate obsolescent rolling mill engines, and one is not justified in considering exhaust steam as a natural heat resource of a works—in fact, it is an asset of a more than doubtful character.

If a balance sheet be prepared, setting down on one side the cost of purchasing power from the local power supply authority and on the other side the cost of power purchased by the steel works themselves from plant installed for that purpose and assuming that all costs, such as capital and obsolescence charges, are included, it will be found that if the steel works' demand for power is large the cost of power produced by the steel works themselves will be less than that at which it can be purchased from a power supply authority.

The author believes that the engineering side of an iron or steel works should be treated in the same manner as the commercial side, in that it should be the subject of a series of regularly prepared balance sheets, which should be subjected to scrutiny at stated intervals.

Mr. Walter Dixon said the paper was to be regarded as a contribution, not to the engineering, but to the economic aspect of the question. There were many factors which had not been taken into consideration in the paper, but which might alter somewhat the conclusions stated. In theory he agreed with the author's deductions, but it depended on circumstances and on the application of them, how far it would be wise to apply them in practice.

Mr. F. Clements wanted more information on certain points. Under "(a) High Load Factor," the author gave two tables for the cost of power, first of all with steam plant, by which he supposed he referred to gas-fired boilers and high-pressure steam turbines, and, secondly, with low-speed gas engines. It depended, he supposed, on the size of the plant that was being considered. At the present time a steel works of fairly large capacity would not demand much more than 6000 kilowatts in the generating station. He would like to know what size of unit the author had in view, and also whether the capital depreciation of spare units—if spare units were to be allowed—was provided for. In the case of the water, oil and stores for steam plant, the figure at 65 per cent. load was 0.02d., while for gas engine plant it was 0.03d. with the same load factor. Had the author included in those figures for the steam plant the cost of preparing boiler water and dealing with condenser water? It seemed to him, moreover, that the figure of 0.02d. was a low one for gas engine plant. It depended largely, of course, on the size of the unit employed. He had lately investigated, with considerable interest, the latest developments in gas engine practice in Belgium, and had found that gas engine units were running successfully in Belgium at the present time which would develop 6000 kilowatts. Those, he imagined, would be the largest gas engines in the world. That development was largely due to the fact that the builders, Messrs. Cockerills, had adopted the policy of increasing the average temperature throughout the explosion cylinder, and were using pressures of 80 lb. to 85 lb. instead of 60 lb. to 65 lb., which had previously been looked upon as the maximum, with consequent increase in the power developed by a unit of given size. It seemed to him that, with the adoption of larger units, the cost of generation on the gas engine side would be materially reduced.

Mr. L. Rothera referred to the question of power in the driving of rolling mills. That was a point which, up to the present, he thought, had been somewhat overlooked. From the electrical standpoint, of course, great anxiety was always manifested that the electrical plant should be extraordinarily efficient, and a variation of 1 per cent. was considered a large difference between two tenders for electrical plant. Such a difference in efficiency on the drive, however, was absolutely negligible compared with the losses that might take place in the mill itself. The paper showed very clearly the effect of a 50 per cent. increase in the friction loss of a mill. He knew of actual cases where, after a mill had been running for some time, the friction loss had increased by more than 30 per cent. One of the advantages of the electric drive, was that such an increase was immediately detected.

Mr. F. Anslow said that most of those who were responsible for the installation of electric and other generating plant were fully aware of the importance of load factor. He did not think, however, that steel works' managements were quite so well aware of the importance of this subject. The author had done good service in bringing it up, and this was clearly revealed in the case of the utilisation of exhaust steam. He would like to emphasise the author's point that a saving of 15 per cent. in the coal bill did not necessarily mean a 15 per cent. saving in the power bill. On the fuel question generally, very considerable developments were being made in the utilisation of powdered fuel. He agreed that, under the right conditions, powdered fuel was going to be a great asset to many iron and steel works, but, having in view the very important question of load factor, and other complications, it was important not to overdo the utilisation of powdered fuel without taking all the possible effects into account.

Mr. C. A. Ablett, in reply, said that in the case of the plant referred to in the tables, it was assumed that 6000 kilowatts were actually running, but that in addition to the 6000 kilowatts of plant running there was a 50 per cent. reserve, so that there was 9000 kilowatts of plant altogether. The capital charges had been taken on the whole of the 9000 kilowatts of plant, water, oil and stores, and some of the other charges which appeared in the tables were brought down to the nearest second place of decimals. In the charges given in connection with steam turbine plant with gas-fired boilers, it was assumed that the water for the boilers did not require treatment, but the cost of dealing with the condenser water, *i.e.*, the cost of the cooling power plant, had been included. Mr. Clements' remarks about the Belgian gas engines were of very great interest, because it would appear that, if the Belgians had succeeded in increasing to the extent suggested the average temperature in the cylinders, they were on the path to a real advance by the introduction of larger units, and thus cheapening the capital cost of gas engine plant as a whole. That, of course, would eventually lead to a reduction in the cost of producing power by means of gas engines. On the subject of improvement of load factor, it was very difficult to make any general statement, because the opportunity for improvement varied so much in different works. Naturally, in a case where five rolling mills were driven from the station instead of one, the load factor would be improved; but there was also a great deal of other plant to be considered, and, personally, he had come across a number of cases where, when attention was given to improving the load factor, means of working the plant were found which materially helped to that end.

A paper by Professor Cecil H. Desch and Mr. Aubrey T. Roberts, "Some Properties of Steels Containing Globular Cementite," was then taken. A synopsis of the contents is given below.

GLOBULAR CEMENTITE.

The work described in the present paper was undertaken in order to determine certain properties of high-carbon steels in which the cementite has been brought completely into the globular condition by combined thermal and mechanical treatment. The first section deals with the effect of heat treatment on a carbon steel (1.28 per cent. carbon) slowly cooled from the molten state, and heated under such conditions as to produce globular cementite. Belaiew has shown that it is under such conditions that a damascened structure is obtained. In the experiments now described the forging was not carried so far as to yield damascened steel, but some observations supplementary to those of Portevin and Bénard were made regarding the process of agglomeration of the cementite. Mechanical tests of the same steel in three different states have also been made, together with hardness and impact tests of steels of lower carbon content for purposes of comparison. The second part of the paper describes experiments on the steels used in the manufacture of safety razor blades, with an account of the factors which determine their efficiency. It was remarked by Stead that the cementite in these blades is in the globular condition.

Dr. F. C. Thompson said the paper gave the death blow to the Japanese heresy that the production of spheroidal pearlite depended on taking the material to a temperature above the A1 point. The authors were to be congratulated on their success in bringing out the structure of the spheroidal steels at high magnifications. He could confirm the statement that as the temperature was raised, the boundaries of the crystal became more and more straight. It seemed to be a perfectly general rule that at higher temperatures the crystals became less irregular, and there was therefore less definite interlocking. The work done in connection with the impact value was also of considerable interest. It would have been expected that the impact value would fall when normal pearlite was converted into spheroidal pearlite. The evidence the authors had put forward, showing that the impact value was reduced by coalescence, was most interesting, and, so far as he was concerned, quite unexpected.

Mr. J. H. Whiteley reminded the meeting that the fact that spherodising the cementite could give a lower impact value was not a new discovery. As to the reason for that low impact value, he would like to refer to a paper presented to the present meeting by Messrs. Benson and Thompson, in which it was stated that heating steels below the Ac1 or Ar1 points caused a large growth in the grain. That might really be the cause of the low impact value—because the grain size was growing, or had grown, considerably. The effect obtained by forging steel between 800 deg. and 900 deg. Cent., and subsequently heating it for three hours at 670 deg. Cent., was interesting. Could the authors give any reason why hammering and forging should destroy the solid solution between 800 deg. and 900 deg. Cent., causing the pearlite subsequently to break up more quickly? Was there any difference between a steel forged at that temperature and one allowed to cool down in the ordinary way, so far as the structure of the pearlite was concerned?

Colonel N. Belaiew pointed out that the globular cementite was the structure of damascened blades, which, of course, was one of the reasons why, in addition to the scientific importance of the paper, the results obtained were of such interest. The authors had clearly shown that in many blades made to-day, if not in all of them, the structure was exactly the same as in the damascene blades. The structure of damascened blades, however, was not the result of the spherodised structure of the cementite particles; it was, as was known from the blades in several collections, the result of the primary structure. The old Indian maker was always at pains to produce, first of all, in his damascened cake that primary structure, and only afterwards, with infinite pains, did he try to forge his disc in a certain manner to develop that redistribution of the axes of the primary crystals which would show the damascened structure. In many tools, if the carbon content was high, the maker was, consciously or unconsciously, getting the damascened structure of spherodised cementite, and the same was true to a certain extent in the case of alloy tool steels. Photographs 12 and 19 showed this quite clearly, and gave proof that the structure of many of the modern blades and tools, when their carbon content was high, was exactly the same structure as was unconsciously arrived at in India and Persia many thousands of years ago.

Dr. Hatfield said that the problem of why a razor would sometimes cut and sometimes would not cut, was a very old one in Sheffield, and, much as he would like to do so, he was afraid he could not regard the explanation offered by the authors as being at all convincing. The process of manufacture led to the spherodisation of the cementite, and, when one examined a razor it would be seen that the spheroids cancelled each other out. After all, it was the craftsmanship of the razor-maker which gave either a good or a bad razor. He did not wish to be too critical, but he had given a great deal of attention to the subject, which was a very important one for Sheffield, and the fact was that, after all the inquiries that had been made, it was not possible to say conclusively why razors sometimes would not cut.

Professor C. H. Desch, in reply, said the authors had not touched on the question of ordinary razors; their remarks applied only to safety razor blades. The structure of the ordinary old-fashioned Sheffield razor was not the same as that of a safety razor blade; it was much more complex, and the heat treatment was very much more complex. They had examined a very large number of different makes and consignments of blades, and had always found that, in a good blade, the distribution was very uniform and the particles were of uniform size. In a bad blade they were irregular. It had been found that that distribution depended on the distribution of the cementite in the original rolled strip. It was of interest to mention that the best blades made in America—those which had the highest reputation as safety razor blades—were made from strip manufactured and rolled in Sheffield.

A paper by Mr. T. P. Colclough, entitled "The Constitution of Basic Slags: Its Relation to Furnace Reactions," was then read. The conclusions reached by the author are given below.

BASIC SLAGS.

1. The slag formed in a basic open-hearth furnace is essentially tetra-phosphate of lime with monosilicate of lime, magnesia and manganese oxide.

2. The addition of "acid" oxides to such a slag causes instability, and leads to a return of phosphorus to the metal.

3. Additions of "basic" oxides merely pass into solution and the type of compound is not altered. In certain cases there is probably a compound of lime and ferric oxide formed, which is comparatively stable.

4. When an excess of lime is present, MnO is carried in solution and, under certain conditions, is reducible to manganese.

5. The relative rates of oxidation of carbon and phosphorus depend primarily on the basicity of the slag, and there are two "critical" compositions :—

(*a*) When the total bases are sufficient only to form the slag given in (1) there is no further oxidation of phosphorus, and carbon is eliminated.

(*b*) When the lime content is sufficient to form the silicate and phosphate, carbon remains constant until nearly all the phosphorus is eliminated.

6. The removal of sulphur is only indirectly due to the presence of a high lime content—the direct agent is manganese, which is thrown into the bath from the slag.

Mr. E. H. Saniter said the paper was a plain statement of facts, which should be useful to steel makers. There were one or two points, however, to which the author had not given full weight, particularly to the *rôle* played by oxide of iron. Oxide of iron played a double *rôle* in the process ; it was, of course, an oxidiser, but in any quantity it was also a very strong base, and could remove the phosphorus independently of the lime. On the sulphur question he could not accept the author's explanation. In the first place, there was a very great difference between the temperature in the Siemens furnace and that at which the reactions took place in the mixer by the Massenet process. The author, perhaps, attached more importance to manganese because the pigs he was accustomed to work contained a high percentage of manganese ; but in the Cleveland district, the manganese in pig iron was only 0.5 or less.

Mr. J. H. Whiteley said that in Table II. the author referred to a basic slag containing no ferrous oxide. Before that was accepted as correct, he would like to ask the author whether he had allowed, in the analyses, for the possibility of a higher oxide of manganese being present, say, Mn_3O_4, for example.

Professor Thomas Turner said he had in contemplation some experiments, which would be very difficult, no doubt, and which, perhaps, might lead to nothing, but which would have for their object the determination of the reactions of the slag by the electro-chemical method. It was by a method of that character that the actual reaction point between the fluid mixture of slag and the fluid metal would be determined.

A paper by Dr. D. Hanson and Mr. J. R. Freeman, jun., "The Constitution of the Alloys of Iron and Nickel," was next on the list. The research described in this paper was undertaken at the National Physical Laboratory, and is a continuation of the investigation carried out by D. Hanson and Hilda E. Hanson, in which the constitution of the nickel-iron alloys at temperatures below 900 deg. Cent. was determined. The present authors have extended this work by determining the constitution of the alloys up to their melting points. The only previous investigation of this kind is that of Guertler and Tammann, who determined the freezing point curve. The $\delta \longrightarrow \gamma$ transformation, then undiscovered, does not appear in their equilibrium diagram. A further determination of the constitution, using the purest available iron and nickel, therefore appeared necessary.

Dr. W. Rosenhain said the paper had been undertaken some little time ago in anticipation of a much wider programme, of which it really formed the beginning. They, at the National Physical Laboratory, were contemplating the undertaking of the systematic study of the alloys of iron and other elements, in the first place, free from carbon. A very remarkable alloy had been discovered in the series. It was a carbon-free iron-nickel alloy. It had been discovered in the laboratory of the Western Electric Company in America, and had been very thoroughly patented and was being exploited. It was an alloy containing 81½ per cent. of nickel and 18½ per cent. of iron. The alloy had a very strongly marked definite composition, and if that composition were departed from the remarkable qualities were lost. Those properties were mainly interesting from the magnetic point of view. The material had the property of becoming magnetically saturated under a very low magnetising force, and its permeability was thousands of times greater than that of pure electrolytic iron. It was a material of very remarkable magnetic properties which were highly unstable. It was likely to be of practical importance because it could be wound on a copper inductor as an inductance loading for telegraph and telephone cables, and it was likely to prove of considerable value as enhancing the rate of transmission over such cables and improving the clearness of telephonic conversation. An interesting point was that when it was wound round a copper cable the mere winding strained the alloy sufficiently to spoil it magnetically, and the whole conductor—the copper with the alloy wound upon it—had to be annealed afterwards in order to re-soften that alloy. It was a remarkable instance of an alloy of a group, apparently only of fundamental scientific interest, proving likely to be of practical value. It emphasised the point which he had been trying to make for a considerable time, that a research on fundamental alloys of iron with other metals was almost certain to lead to extraordinarily valuable results.

At the last session of the meeting on May 11th the first paper on the list was an interesting contribution by Professor C. A. Edwards and Mr. Charles R. Austin, "A Contribution to the Study of Hardness." For the purpose of a joint discussion Mr. Hugh O'Neill also presented his paper, "The Variation of Brinell Hardness Number under Testing Load." Extracts from these two papers are given below.

HARDNESS.

There does not appear to be any simple relationship between the rebound method of measuring hardness and Brinell's static method, and it is therefore not readily possible to express one in terms of the other by the use of a conversion scale. If only small amounts of energy are used in the drop test there is comparatively very little difference in the height of rebound that is produced after striking metals whose hardness is above a Brinell value of, say, 300. Hence rebound observations under these conditions are worthless for the purpose of discriminating between hard materials.

This limitation, however, becomes less serious as the height of fall is raised, and there appears to be some reason for considering that there might be a linear relationship between the rebound and Brinell values if the height of fall were increased to an extent which has not yet been ascertained. This state of affairs is approximately reached, when using an unloaded 10 mm. steel ball, if the height of fall is 75 cm. There are, of course, many practical objections to using an instrument to give so great a height of fall ; but if, as would appear from previous work, the velocity of impact is not an important factor, then it should be possible to get perfectly satisfactory results by using a loaded ball.

In the Brinell hardness-rebound diagrams the anomalous positions of tin, mild steel and cupro-nickel may be noted. Each of these substances gave a higher rebound for any given fall than would be expected from their hardness as measured by Brinell's method. This peculiarity has been previously noted for tin and mild steel as well as two other pure metals, namely, zinc and cadmium, and it is thought to be in some way associated with the formation of definite twin lamellæ when these metals are suddenly stressed. The authors have not so far been able to detect this kind of structure in the case of cupro-nickel.

A simple relationship between Brinell values of different metals and heights of rebound obtained from heights of fall or energy of impact yielding a constant amount of deformation has been obtained.

BRINELL HARDNESS.

1. The curve showing the relation between the indenting load and the resulting Brinell number commences at the origin and rises steeply at first. It then flattens out and passes through a maximum, subsequently falling until the ball is embedded in the specimen.

2. The Brinell number is the sum of two terms, the second of which is equal to the first multiplied by a factor. This factor decreases in value from 1.0 to zero as the testing load increases over the range of the test.

3. Up to the maximum in the load-hardness curve this factor is of such a value as to permit of the following approximate relation :

$$H = K L^x.$$

4. The curve ends when the ball is immersed up to its diameter in the metal. The Brinell number and load corresponding to this point have been called the "ultimate hardness" and the "ultimate load" respectively. There is a linear relation between the two for all metals.

5. The harder the material the higher the maximum value of the Brinell number and the greater the load at which it occurs.

6. Viscous materials obey Meyer's formula and have a value for *n* of 2.0. Their Brinell number is a maximum when L = O, and decreases as the testing load increases.

7. The effect of cold work upon a metal is to raise the maximum Brinell number and to decrease the value of the load at which it occurs. The "ultimate hardness" and the "ultimate load" appear to remain constant.

8. It is probable that after a certain amount of deformation in the cold the rigidity of a metal decreases.

Mr. O'Neill, dealing with Professor Edwards' and Mr. Austin's paper, said it put forward the conclusion that the energy expended in making indentations by the dynamic method varied lineally with the volume of the indentation. A Japanese investigator had reached the same result. Personally, he thought it would have been interesting if Professor Edwards and his colleague had carried out the scleroscope determinations of hardness with the object of ascertaining to what extent they agreed with the energy required to produce an indentation.

Professor C. A. Edwards, dealing with Mr. O'Neill's paper, asked him to define his "ultimate hardness" figure.

The next paper taken was that by Mr. Charles R. Austin, on "Some Mechanical Properties of a Series of Chromium Steels," which is a record of the effect of heat treatment on the mechanical properties of a series of chromium steels, consisting of two groups of steels containing about 0.35 per cent. carbon and 1 per cent. carbon respectively, the chromium content varying from 2 to 12 per cent.

Mr. J. A. Jones referred the author to some work done by Dr. Moore at Woolwich about seventeen years ago, which was originally published in 1907 and had been since reprinted as Research Department Report No. 35. It was a very detailed examination of the mechanical properties, including elastic limit, yield point, and other properties of chromium steel containing up to 6.4 per cent. of chromium and with .350 carbon. With reference to annealed steel, the following conclusion by Dr. Moore might be of interest. Dr. Moore found that up to 2.5 per cent. of chromium the maximum stress was raised and the elongation correspondingly reduced, but that with an increase of chromium up to 3 per cent. the maximum stress appeared to fall off. For purposes of comparison it would be of interest if the author could give the rate of annealing.

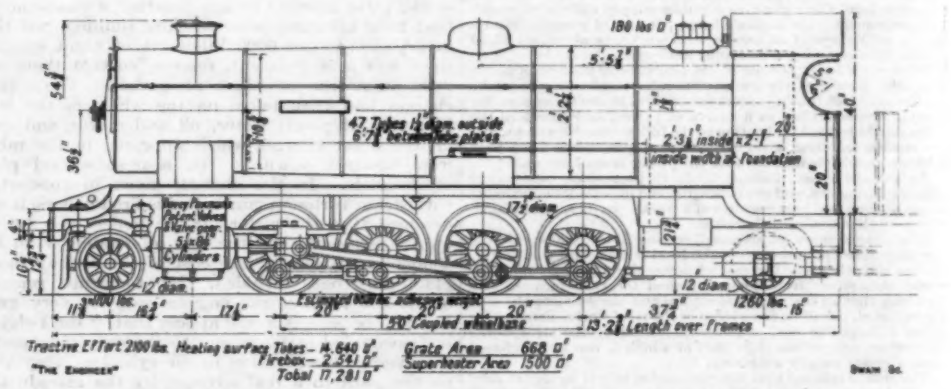
Mr. Jones then presented a paper dealing with "The Ac1 Range in Alloy Steels," on which there was a very brief discussion.

The following papers were presented but not discussed :—"An Investigation of the Behaviour of Certain Steels under Impact at Different Temperatures," by Mr. F. C. Langenberg, Watertown Arsenal, U.S.A.; and "The Cold Working of Steel with Reference to the Tensile Test," by Mr. John Stead.

The proceedings terminated with a vote of thanks to the Institution of Civil Engineers.

New Locomotive, Ravenglass and Eskdale Railway.

To cope with the new mineral traffic on the Ravenglass and Eskdale 15in. gauge railway, which, at the present rate, increases the services by about 70,000 ton-miles per annum, a new engine of the 2–8–2 tender type has been designed by the company's engineer, Mr. Henry Greenly, and ordered from Davey, Paxman and Co., Limited, Colchester. The original design has been modified so as to permit the use for test purposes of the Lentz poppet valves and valve gear. The valve motion is arranged inside the frames and operated by the second coupled axle. The locomotive is designed to negotiate 80ft. radius curves, the front truck wheels being connected with the leading coupled axle on the Krauss principle. The frames are inside and are ¾in. thick, and among the several special features embodied in the design are the arrangement of outside springs on the leading and trailing trucks and large sand-boxes. The engines of the new class are intended to haul 32-ton trains up long banks of 1 in 60 and shorter gradients of 1 in 34 to 1 in 40. They will be fitted with the simple vacuum brake, and although the gauge is so small, the cab will give complete protection for the driver. The tender will be of the eight-wheeled type, holding 130 gallons and 5 cwt. of fuel.



A MINIATURE MAIN LINE ENGINE FOR THE RAVENGLASS AND ESKDALE RAILWAY

General Dimensions.

Gauge	15in.
Cylinders, two	5½in. by 8½in.
Coupled wheels	17½in. dia. on tread
Truck wheels	12in. dia. on tread
Width over footplates	3ft. 2in.
Overall length, engine and tender	23ft. 3in.
Estimated total weight of engine and tender	6 tons 2 cwt.
Boiler barrel at smoke-box end	1–10½in. dia.
Boiler plates	⅜in.
Tubes, forty-seven	1¾in. dia. outside
Heating surface—	
Tubes	14,640 sq. in.
Fire-box	2,541 sq. in.
Superheater	1,500 sq. in.
Total	18,681 sq. in.
Grate area	668 sq. in.
Fire-box, outside at foundation ring	2ft. 8½in. long by 2ft. 6in. wide
Tractive effort	2100 lb.

In connection with the granite traffic from the Beckfoot Quarries and the Murthwaite crushing plants, considerable improvements recently have been made to the equipment of this small line, including an overhead siding and rolling tip at Ravenglass for loading roadstone into the main line —Furness Railway—wagons.

ACID-RESISTING irons generally contain 13–15 per cent. of silicon, with sulphur, phosphorus, carbon, and manganese present in comparatively small quantities ; the remainder is iron. Resistance to corrosion increases with the silicon content, but above 15 per cent. the increased resistance does not outweigh the extra cost. For severe corrosion conditions, a minimum of 14 per cent. silicon and a maximum of 0.80 per cent. carbon should be stipulated. A lower silicon content, particularly if accompanied by an increase in carbon, would increase the rate of corrosion several hundred times.

A Seven-Day Journal.

Reduced Locomotive Building Activity.

ALTHOUGH reports continue to be issued of orders being placed in this country for locomotives, the fact has apparently to be admitted that the work being received is not of sufficient amount to keep the old-established firms building railway engines and those which since the end of the war have entered, or revived their interest in, the industry, in anything like full employment. We regret to notice that the North British Locomotive Company, Limited, has had to decide to dispense with the services of a considerable number of its workmen engaged at the Atlas Works, Springburn, Glasgow—formerly Sharp, Stewart's. For some time past the company has succeeded in keeping its three works—Hyde Park, Queen's Park, and Atlas—in something like fair employment by distributing the orders received among them. That policy apparently can no longer be continued, and it has become necessary to concentrate the work in hand at two of the establishments. The Atlas Works, we understand, will not be completely closed down. The directors express the hope that in the near future trade will improve to an extent permitting the company to resume its operations on the usual scale, and give employment to its workmen many of whom have been in its service since their boyhood.

Local Authorities and Their Contracts.

THE many cases recently reported in which town councils and other local authorities have, for the sake of financial economy placed orders for material abroad, have apparently been receiving close attention from the Government. At the end of last week the Minister of Health addressed a letter on the subject to the local authorities of England and Wales, in which it was stated that as a condition of granting assistance to any scheme of work designed for the relief of unemployment, the Government would now require that all contracts for or incidental to the work must be placed at home. The letter also urged that the same principle should be followed by all local authorities in connection with the placing of contracts, even when the expenditure on the works was not assisted by grants from the Treasury or Road Fund. The Government's attitude on the matter, as thus expressed, has given great satisfaction in business circles, and particularly to the Federation of British Industries, which has been using its influence in this direction for the past four or five months. In this connection, the attention of Parliament is to be directed to the action of the Glasgow Corporation in accepting an American tender for the supply of tramway material at £9000, although an English firm quoted a very near figure, and subsequently offered to reduce its price to the American level.

The World's Largest Submarine.

THE submarine X 1, which was laid down at Chatham Dockyard on November 2nd, 1921, under the Navy Estimates for that year, proves to be the largest vessel of this type at present in existence. Her displacement, as given in "Particulars of British War Vessels," an Admiralty publication, is 2780 tons on the surface and 3600 tons submerged. No other details as to her dimensions, machinery, or armament are available for the time being. Hitherto the largest submarine completed was the German "U-cruiser" No. 142, which had a surface displacement of 2158 metric tons. Other submersible cruisers, some displacing 2400 tons, were on the stocks in Germany at the Armistice, but were never completed. Next to the X 1, the heaviest submarine in the British Navy is the K 26, a steam-driven boat of 2140 tons on the surface and 2770 tons submerged, which is about to be commissioned at Chatham. The earlier "K" boats are of 1880/2560 tons, and the "M" class, submarine monitors carrying one 12in. gun apiece, displace 1600/1950 tons. The X 1 thus marks a considerable advance in the development of the submarine, and further particulars, especially of her propelling machinery, will be awaited with keen interest.

Apprentices and Indentures.

THE attitude of the trades unions towards apprenticeship has not always been free from hostility, as, for instance, in the restriction commonly placed on the number of apprentices which may be employed relatively to the number of skilled journeymen. The laws governing apprenticeship are, of course, of ancient origin, and are considerably older than any trade union in existence to-day. Partly because of changed conditions and partly because of the hostility of the unions, the laws and customs of apprenticeship have now fallen into desuetude, so much so, in fact, that nowadays it is quite common in some districts to find engineering and shipbuilding apprentices who have never been asked or required to sign proper indentures. As one clause in an indenture of apprenticeship usually specifies that the apprentice shall not take part in any strike among the body of the workmen, and as in the past important works have frequently been kept going in times of friction by means of apprentice labour, the tendency to dispense with indentures, one would have thought, would have been welcomed by the trades unions. On the contrary, the Federation of Engineering and Shipbuilding Trades at its annual assembly, which closed at Nottingham last Friday, deplored the situation and declared its determination to take the matter up at once, with a view to securing the adoption of a uniform legal type of indenture for apprentices aiming at becoming skilled journeymen. It was argued that in the absence of proper indentures, boys were not being given the prospect of reaching the higher stage, and that as a consequence the maintenance of our overseas trade and commercial supremacy was being threatened by the production of inferior articles. Craft efficiency and continuity of apprenticeship, it was held, must be preserved on an adequate basis.

Paper Works By-Products.

IN our "Sixty Years Ago" paragraph in last week's Journal we mentioned the proposal of the owners of a Dartford paper mill to produce by the action of steam on a mixture of cotton and wool a substance "ulmate of ammonia," which it was claimed could replace Peruvian guano as a fertiliser. The waste products of paper mills continue to this day to receive the attention of economists, for the scope is considerable, although the difficulty of collecting and treating the various classes of waste in a commercially practicable manner is great. We note with interest that a Midlothian firm—William Tod, Junior, and Co.—claims to have perfected a process for making a new electrical insulating material from various waste products produced in its paper mills. The new substance, to be called "indurite," is said to be superior in some respects to vulcanite or ebonite, and has been favourably reported upon by Professor Bailey, of Edinburgh.

The Norton and Gregory Scholarships.

IN the Journal for January 10th we announced that Norton and Gregory, Limited, the mathematical instrument makers of London, had arranged to offer two annual engineering scholarships, one valued at £100 per annum and the other at £50, each tenable for three years at any approved British or Imperial University. Entries were duly received, we are now informed, from 266 candidates, of whom the committee in charge of the scheme invited 187 to sit for examinations at six different centres throughout the country. The committee finally awarded a scholarship of £25 per year, tenable at Cambridge University, to Rollo Houghton, of Bradfield College; one of £75 to Denis Moody, of the Central Foundation Boys' School, London, tenable at University College, London; and one of £50, tenable at Cambridge University, to Frederick Rapley, of Sunderland Bede Collegiate Boys' School.

A New Atlantic Cable.

ACCORDING to a message received from New York, Mr. C. H. Mackay, chairman of the Commercial Cable Company, has announced that that company is about to lay a new cable across the Atlantic to give direct communication between New York and London. The route of the cable will be by way of Nova Scotia and the Azores, at which point it will join up with the company's cable already laid to Ireland, the connection thereafter being completed by a new length of cable between Ireland and England. Altogether, the new undertaking will involve the laying of about 3070 miles of cable. The Telegraph Construction and Maintenance Company and Siemens Brothers are at present engaged on the work, and it is expected that the laying will be completed in August. The cable, according to Mr. Mackay, will have twice the capacity of any now in service between America and Europe, its estimated speed being about 600 letters per minute. The conductor will contain some 1100 lb. of copper per mile, as compared with about 700 lb. in the heaviest existing cable. The total cost will amount to between 10 and 15 million dollars.

A Shipping Amalgamation.

FROM an official announcement we learn that the Royal Mail Steam Packet Company has secured a controlling interest in the old-established Liverpool shipping company of John Glynn and Son, Limited. The Glynn Line was founded in 1811 by Mr. John Glynn, the great-grandfather of the present managing director, and the steamers of the company are well known in the Mediterranean trade. The chief services of the Glynn Line are those connecting the port of Liverpool with the Italian ports of Genoa, Leghorn, Naples, Palermo, Messina and Catania, and we understand that these services will be retained and will still be managed by the Glynn Line. The present fleet comprises some six vessels of 1800 to 3600 gross tons, which have been specially constructed for the Italian trade. The black funnel of the Glynn Line has now been changed to the familiar yellow funnel of the Royal Mail Steam Packet Company, which is a conspicuous feature of all the vessels of this large group.

Richardsons, Westgarth and Diesel Engines.

IN the Journal of June 23rd last reference was made to the decision of the directors of Richardsons, Westgarth and Co., Limited, to set apart the sum of £50,000 for development work in connection with marine internal combustion engines. Speaking at the annual meeting of the company, which was held at Hartlepool last week, the chairman and managing director, Mr. D. B. Morison, stated that a like sum had been put aside during the present year, making a total amount of £100,000 for practical oil engine research work within the two years. The Beardmore-Tosi oil engines, which are being constructed by the firm, are, it appears, now nearing completion. They will be tested under the scheme arranged by the Institutions of Mechanical Engineers and Naval Architects. It was announced that the company had recently taken out a licence to manufacture the Doxford opposed-piston engine. Commenting on the many competitive types of marine machinery now available, Mr. Morison said that whatever type of engine was adopted, it must be supplied at a reasonable price, and, further, it must comply with the shipowners' demand for unquestionable reliability in working at a minimum cost for fuel, engine-room staff and general upkeep.

The Boilermakers' Dispute.

THE action of the Boilermakers' Society in refusing to allow its members to take part in, or to agree to be bound by the results of, the recent ballot taken by the Engineering and Shipbuilding Trades' Federation on the overtime, night shift and holiday work agreement has now resulted in the Federation exercising its powers and expelling the Society from membership of the Federation. The boilermakers on Tuesday issued from their headquarters a counterblast to the effect that their Society really ceased to be members of the Federation, not on the day of expulsion, but several weeks ago, on the date, in fact, upon which they withdrew from the negotiations, and that therefore the action of the employers in locking them out as being a constituent union was incomprehensible and a serious mistake. This curious and belated statement does not seem greatly to affect the real issue at stake.

Sixty Years Ago.

To the modern sanitary engineer, our issue of May 22nd, 1863, will be found of great interest, by virtue of its containing a paper entitled "On an Improved Mode of Collecting Excrementitious Matter with a view to its Application to the Benefit of Agriculture and the Relief of Local Taxation," read before the Society of Arts by Dr. J. L. W. Thudichum. The system advocated consisted of the separate collection of uncontaminated liquid sewage and its application to the land as a manure, a system adopted by the Jews in the desert. Although the idea may even yet be wholly impracticable on the communal scale suggested, the article is none the less interesting to modern readers by reason of the sidelights which it throws on sanitation sixty years ago. Before the Civil and Mechanical Engineers' Society, we notice, a paper "On Giffard's Injector" was read by Mr. (now Dr.) W. H. Maw. In the course of his remarks he dealt with some experiments made on the injector at the Atlas Works of Sharp, Stewart and Co. The partial closing down of these works—since, of course, transferred from Manchester to Glasgow—is referred to in another note on this page. A report was published of the proceedings at a meeting of the Society of Arts Committees of Reference on Mechanics and Engineering, assembled to formulate suggestions for subjects worthy of the Society's attention. Among such subjects were the lighting of railway carriages, substitutes for boxwood and ivory, the protection of iron from corrosion, and reduction in the cost of manufacturing coke. Rear-Admiral Sir Edward Belcher, dealing with corrosion, drew attention to the method formerly used for the prevention of rusting on the barrels of muskets of the "Brown Bess" pattern, namely, by heating them to an extent sufficient to burn stag horn, which was then rubbed over them. The same authority expressed himself on the same occasion as unable to see the necessity for iron vessels in the Navy, and as prepared to unfold in a paper his ideas on the construction of impregnable warships of wood with coppered bottoms.

The New Electricity Distributing Station at Colwyn Bay.

By JOHN B. C. KERSHAW.

THE new electricity station at Colwyn Bay was formally opened by Lord Colwyn on November 30th last, and although of small size, it is of considerable interest to engineers, since it is the first of the motor generating and distributing sub-stations to be operated under the Act of 1919, for the supply of electricity in bulk to the North Wales area. The earlier history and development of this scheme was fully described by the writer in the illustrated article entitled "Actual and Projected Water Power Developments in North Wales," which appeared in the issue of THE ENGINEER for February 25th, 1921. The present article therefore will be restricted to a description of the two sub-stations in Colwyn Bay, which form the final links of the line connecting the central large generating stations at Dolgarrog and Cwm Dyli with the consumer in Colwyn Bay.

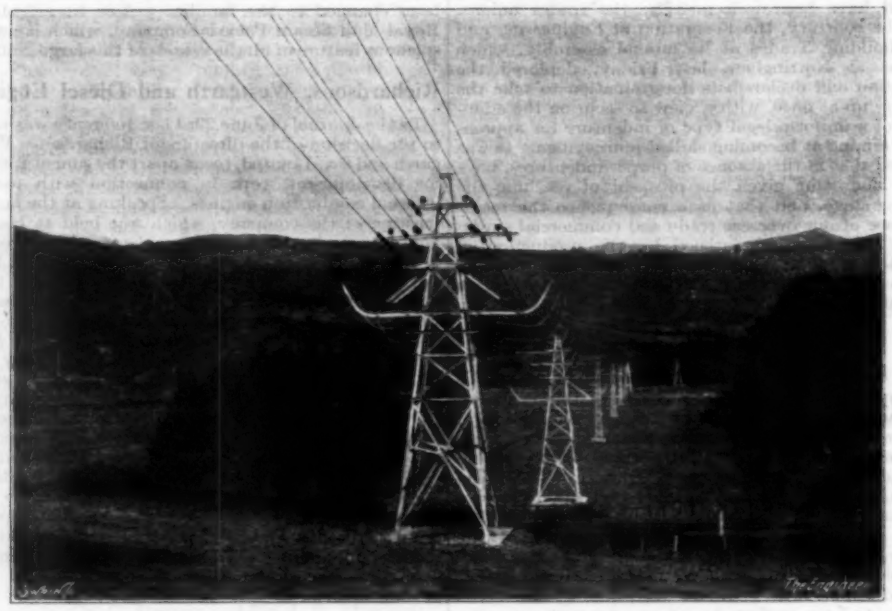


FIG. 1—HIGH-TENSION TRANSMISSION LINE CROSSING THE CONWAY VALLEY

THE SUB-STATION AT BRON-Y-NANT.

The electric current, which is transmitted from Dolgarrog to Colwyn Bay in bulk at 20,000 volts, is reduced to the lower pressure of 440 volts—at which it is distributed within the town to the consumers—in two stages; the first step being the reduction to 6600 volts at the transformer sub-station at Bron-y-Nant, and the second step the reduction from 6600 to 440 volts, by motor converters, at the Ivy-street sub-station in the heart of the town. Fig. 1 shows the high-tension solid copper transmission lines supported on the lattice steel masts, which are employed for carrying the line across the Conway Valley. The Bron-y-Nant sub-station is on the western boundary of the town, close to the gasworks and to the main road from Colwyn Bay to Conway. It is a substantial two-storey brick building, large enough to accommodate three 1000 kilovolt-ampère main transformers, though at present only two are installed. They were built by Ferranti Limited, of Hollinwood, and are of the oil-immersed, self-cooled, double-wound core type. They are contained in boiler plate tanks provided with external cooling tubes, and are similar to other transformers by the same makers which have already been illustrated in our columns.

SWITCHGEAR.

The 35,000-volt switch cubicles for the control of the incoming overhead three-phase transmission lines are fixed on the top floor of the sub-station. There are three incoming feeders, two from Dolgarrog and one which will link through to the Conway sub-station and beyond, thus providing two alternative sources of supply. The extra high-tension switchgear was supplied by Ferguson, Pailin, Limited, of Manchester, and consists of four sheet steel cubicles, containing the necessary isolating switches, oil-break main switches, bus-bars, &c. The switchgear for each phase is contained in a separate compartment. Three cubicles are arranged to control the incoming and outgoing feeders; the fourth controls the supply to the two 1000 kilovolt-ampère transformers through a set of bus-bars with selector switches.

The 6600-volt switchgear was supplied by the same Manchester firm and is of its standard truck type. It consists of three transformer panels, four feeder panels, and also a local supply panel with a 30 kilovolt-ampère lighting and power transformer and low-tension switch panel. The necessary recording meters for indicating and recording the output of each transformer and feeder are mounted on these panels, while the transformer panels are equipped with ammeter, voltmeter, and one integrating watt-hour meter.

The feeders marked Colwyn Bay 1 and Colwyn Bay 2 are each equipped with ammeter, power factor meter, and three integrating watt-hour meters, connected with their current coils in series and potential coils in parallel, for recording the output supplied to Colwyn Bay Urban District Council. The mean of the readings of these three instruments is the amount charged by the power company. The local lighting supply is given at 400/230 volts metered through a special four-wire meter. A 30 kilovolt-ampère transformer supplied by Johnson and Phillips, Limited, transforms down from 6600 to 400/230 volts, and is intended for supply of current in the area immediately surrounding the sub-station, including the gasworks.

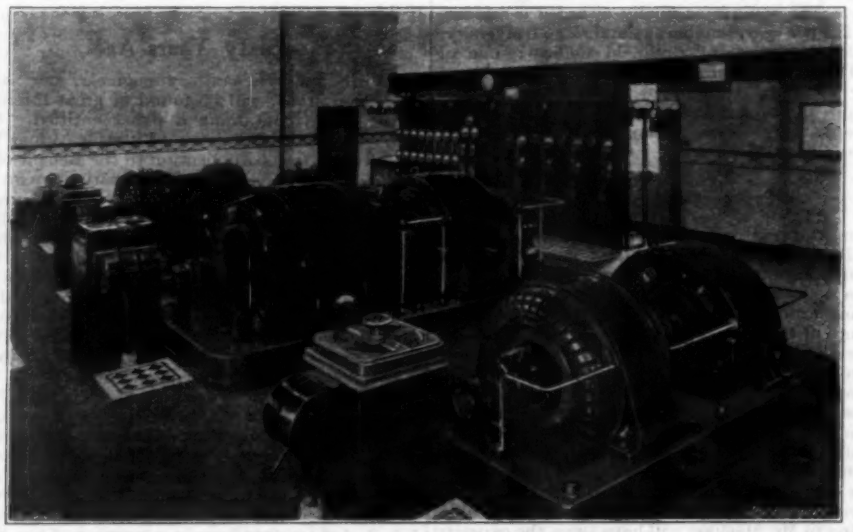


FIG. 2—INTERIOR OF IVY-STREET SUB-STATION

THE IVY-STREET SUB-STATION.

The new distribution station in Ivy-street has been erected on the site of the old fire-engine station, and is a brick building with stone facings and a slated roof. The station is designed to accommodate four 500-kilowatt converting sets with the necessary switchgear, but at present only just over 1000 kilowatts of plant are installed, namely, one 500-kilowatt motor generator, one 300-kilowatt motor generator supplied by Bruce Peebles and Co., Limited, of Edinburgh, and two 120-kilowatt sets which have been purchased from the Rochdale Corporation. Fig. 3 shows a plan of the station and of the high and low-tension switchboards, while Fig. 2 is reproduced from a photograph of the interior of the station and shows the 500-kilowatt motor generator set.

The current is conveyed to the Ivy-street sub-station from Bron-y-Nant by underground cables, laid in duplicate under the footpath of the Conway-road. These cables were supplied and laid by W. T. Glover and Co., Limited, of Manchester, and are three-core—each core .1 square inch copper—paper-

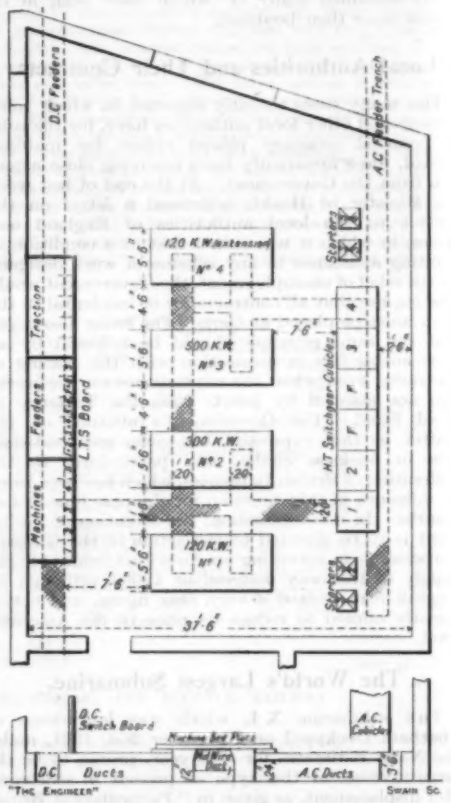


FIG. 3—PLAN OF IVY-STREET SUB-STATION

insulated, lead-covered and steel armoured. They are laid at a minimum depth of 2ft. directly in the ground, with a strong marker board 4in. above them. They enter the sub-station in Ivy-street by a subway along the north side of the building, while the low-tension switchboard is erected on the south side, the cables and connections being run on supports on the south subway wall. The extra high-tension switchgear is of Reyrolle and Co.'s type, with the following units:—Two feeder units, one interconnecting unit, four machine units. Each of the latter is of sufficient capacity to control 500 kilowatts and is provided with the necessary instruments mounted above the switch units. The extra high-tension machine connections are led through earthenware ducts to the various machines and are equipped with Merz-Price protection gear. The extra high-tension switchboard is shown in Fig. 4.

The low-tension switchboard—Fig. 5—comprises five machine panels, one of which is a spare, each designed for 500 kilowatts capacity. The machine panels are complete with lighting and traction bus-bars, the change-over gear being arranged by shutter type plug and switch interlock. This allows for the machine being automatically compounded for a traction load. The feeder panels have provision for eight feeder cables of 0.5 and 0.25 square inches cross section, with double-pole switches to each, mechanically interlocked and provided with the necessary ammeters. The voltmeters for the generating and feeder lines are swung to each end of the board, with selector switches attached. The centre panel is for registering the total output, and contains the necessary watt-hour meters, recording instruments

and earth switches, &c. The connections to the feeder terminal boxes in the subways are taken from the back of the board.

The distribution system in Colwyn Bay is a three-wire one, with a pressure of 440 volts between the outers and 220 volts between either outer and the neutral wire.

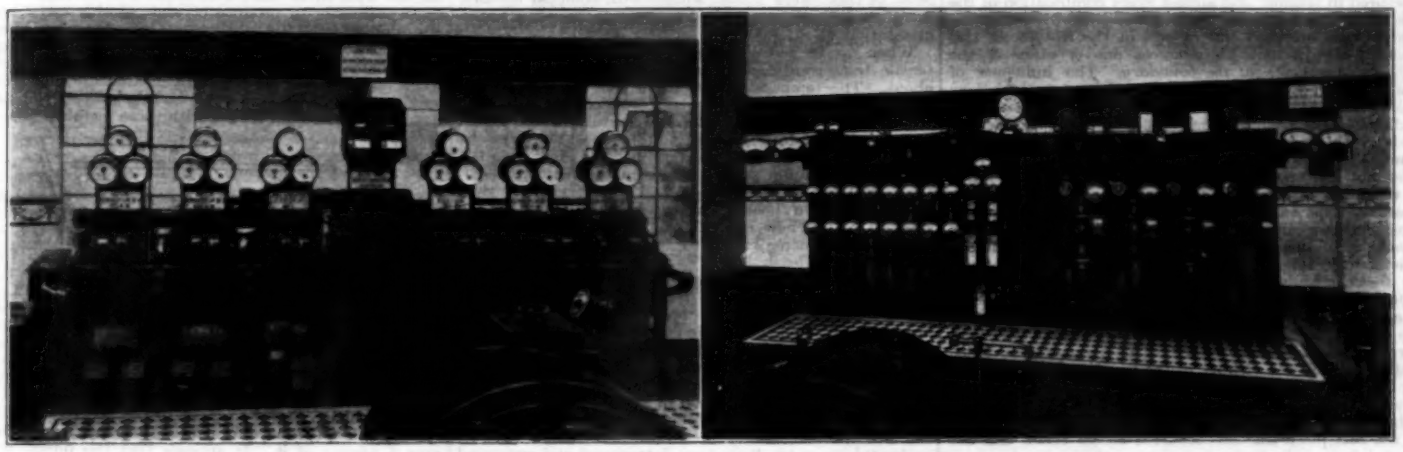
The old steam generating station has always been rather an eyesore to the inhabitants since it was erected in 1901 in the centre of the town, and it is a relief to them to know that it is proposed to dispose of the old plant as soon as the machinery at the new station is in thorough working order. The revenue derived from this sale will be employed in paying off some of the outlay incurred in the erection and equipment of the new station.

Under the new scheme the current is to be supplied by the North Wales Power Company in bulk to the Colwyn Bay Urban District Council at a cost of 1¼d. per unit, and in time no doubt the consumer will benefit by a considerable reduction in the charges for electric current for lighting and power purposes.

Mr. James Smith, the lighting and power engineer of the Council, to whom the writer's thanks are due for aid given in the preparation of this article, is quite alive to the necessity for reducing the charges for electric current, and possibly the first step in this direction will soon be taken.

The estimated actual costs of generation at the new station are slightly under 2d. per unit; capital charges on the old and new loans will amount to 4d. per unit; while distribution and establishment charges will add another 1d., this making the total cost 7d. per unit. When the output of the station is doubled it is estimated that a reduction of 2d. per unit can be made to the consumer, and thus the success of the new supply depends chiefly upon adding to the number of consumers and increasing the output of the station.

The overall efficiency of the new station during the first quarter's working was approximately 78 per cent. This represents a satisfactory return from the plant and distributing system, especially when the low load factor, due to the non-industrial character of the town and district, is considered.



FIGS. 4 AND 5—HIGH AND LOW-TENSION SWITCHBOARDS

The Production of Single Metallic Crystals and Some of Their Properties.*

By Professor H. C. H. CARPENTER, F.R.S. (Royal School of Mines).

THE following paper has been written at the invitation of the Council of the Iron and Steel Institute, following on a suggestion made by Dr. Hatfield at the last annual meeting that it would be of interest to some of the members if Miss Elam and the author would prepare a paper dealing with the production and properties of single metallic crystals.

As a result of a large number of experiments extending over some years, Miss Elam and the author succeeded, about two years ago, in preparing very large crystals of the metal aluminium, and worked out the conditions under which such crystals could be regularly produced. The discovery, therefore, was not a chance one, but was simply the last of a series of experiments logically connected together. Emphasis is laid on this point because, whether the reasoning which led to this result be correct or not, it, at any rate, produced the desired result.

Metals and alloys are composed of aggregates of crystals. Attention is drawn to two of their characteristics. In the first place, they do not, as a rule, possess plane faces—that is, the external forms of crystals. They are joined together at boundaries which have been produced by the meeting of a number of crystals growing simultaneously, and are usually irregular in outline. In the second place, they are usually very small and cannot be distinguished without the aid of a microscope.

The properties of metals and alloys are the properties of these aggregates of minute crystals. Sauveur was the first investigator to show, about eleven years ago, that by carefully straining and subsequently heating metals much larger crystals can be produced, and suggested that there was a critical stress which produced the largest crystals. As subsequent events have shown, this suggestion is perfectly correct. Subsequently, other investigators showed that if a metal was locally deformed and then heated, exceptionally large crystals were formed at some distance from the point at which the strain is severest.

About two years ago we succeeded in converting the whole of the parallel portion of aluminium test pieces, whether in the form of sheets or bars, into a single crystal, which indeed extended for some distance up into the curved shoulders of the test pieces, forming an irregular boundary line. The crystals varied in size from 0.5 to 2.0 cubic inches, and it has been possible to compare some of their properties with those of the aggregates of small crystals of which this metal is usually composed. Experiments have also been carried out with silver, copper and iron, but with less success, although in all three cases it has been possible to grow crystals very much larger than those contained in the original metal.

We have studied the structural changes produced in a crystal aggregate by deformation, followed by heat, very carefully. They may be summarised broadly in the following way:—The first effects of strain are slight. They are revealed by the presence of slip bands, and in some cases twinned crystals. The former are completely, and the latter to some extent, removed by heating. No change is observed in the shape of the crystals. The boundaries appear unaffected, and, apart from twinning, there is no change in orientation. Thus far, only the interior of the crystals is affected. Somewhat greater deformation, however, followed by heat, produces actual crystal growth, and at this stage the boundaries of the crystals become active. The activity is shown in the capacity of the growing crystal to push forward its boundary in certain directions, thus invading other crystals, but even at this stage the orientation of the growing crystals is maintained. That of the crystals grown into is of course destroyed, unless it happens to be the same. A still greater deformation produces the third stage, which appears to take place exclusively in the boundaries of the deformed crystals. It is here that new crystals are born, indicating the destruction of the original crystals and the production of a new orientation. Whereas, therefore, the early effects of deformation are shown only in the interior of the crystals, the later ones appear to take place entirely at the boundary. Accordingly, it will be seen that, from the point of view of producing large crystals from an aggregate of small ones, the intermediate degree of strain just referred to is the important one.

THE PRODUCTION OF SINGLE CRYSTALS IN ALUMINIUM SHEET.

The problem which we set ourselves was to convert the crystals in the parallel portion of a test piece, 4in. by 1in. by 0.125in. into a single crystal. These test pieces were machined from a hard rolled aluminium sheet and subsequently heated. After this treatment, which produced complete recrystallisation, there were about 150 crystals to the linear inch. Calculation shows, therefore, that the total number of crystals contained in the parallel portion of the test piece was about 1,687,000. The experiments have been carried out with metal of the highest purity obtainable (99.6 per cent.). In order to convert the parallel portion of these test pieces into a single crystal three treatments are necessary, two of them thermal and the third mechanical. The sheet as received was in the cold-rolled condition, the crystals being very much elongated and worked into one another. It had first to be heated, so that it might be completely softened and new equiaxed crystals of approximately uniform size produced. It had next to be strained to the required amount, and finally it had to be heated so that the potentiality of growth conferred by strain could be brought fully into operation. The details of these three treatments are summarised in the following paragraphs:—

(1) *The Temperature and Time of Heating before Stressing.*—The most suitable temperature was found to be 550 deg. Cent., and the time six hours.

(2) *The Stress Applied and the Percentage Elongation Caused.*—The procedure finally adopted was to pull to some definite fraction of a ton per square inch, which would give approximately the required elongation. A load of 0.20 ton, *i.e.*, 1.6 ton per square inch, gave an elongation of 0.8 per cent. on 3in. If such a test piece was subsequently heated, large crystals were produced, but some small surface crystals frequently remained unabsorbed, even after many hours' heating at 550 deg. to 600 deg. A load of 0.30 ton finally proved the most suitable.

(3) *The Temperature of Heating after the Application of Stress.*—Each test piece was placed in a furnace whose initial temperature was 450 deg. Cent., and the temperature raised at about 20 deg. to 30 deg. per day up to 550 deg. Cent. It was then subsequently heated for one hour at 600 deg. Cent. in order to complete the absorption of small crystals on the surface, which persistently remained at lower temperatures. This method proved on the whole to be the best, but, even so, on an average not more than one test piece in four is converted into a single crystal over the parallel portion, the boundaries at each end extending in an irregular manner into the wide heads. The time required for a single crystal to form from the 1,687,000 originally present can only be stated approximately, but in the majority of cases the result can be achieved in from 72 to 100 hours. A test piece is, of course, much more quickly converted into three or four large crystals than into one, since in the former case growth takes place simultaneously from several centres.

If the optimum conditions for the production of a single crystal throughout the parallel portion of the test piece are maintained, on an average one experiment in four is successful. There are, however, considerable variations from batch to batch, *e.g.*, in a given case, eighteen test pieces, which had received as nearly as possible the same heat and mechanical treatment, gave the following results, which must be understood to refer only to the parallel portion of the test piece, 4in. by 1in. by 0.125in. Two test pieces consisted of one crystal, six of two crystals, five of three crystals, three of four crystals, and two of six crystals. In another batch, out of twenty test pieces, seven consisted of one crystal, eight of two crystals, four of three crystals, and one of four crystals. The best result hitherto achieved has been in a batch where nearly half the test pieces were converted into a single crystal over the length in question.

TENSILE STRENGTH TESTS.

When composed of small crystals—about 150 to the linear inch—as obtained by heating for six hours at 550 deg. Cent., the sheet gives uniform results on breaking. The ultimate stress varies from 4.5 to 4.7 tons per square inch, and the percentage extension on 3in. from 36 to 38. The sheet necks slightly at the fracture, which is usually straight. This is the standard of comparison from which the behaviour of single crystals may be judged.

The values obtained in tests of specimens consisting of single crystals varied from 2.80 to 4.08 tons per square inch, while the extension varied from 34 to 86 per cent., measured on 3in. These variations in properties were accompanied by differences in the method of stretching and the types of fracture, and these have provided a means of classifying them. In certain cases the mechanical properties, especially the extension, were found to be closely related to these characteristics. Speaking broadly, five types may be distinguished.

Type I.—The test pieces narrowed in breadth gradually from the shoulders towards the fracture. The reduction in breadth near the fracture was often great, *e.g.*, the metal necked sometimes almost to a point. The sides—machined edges of the sheet—remained perpendicular, and the reduction in thickness was only from 2 to 3 per cent. The tenacity was found to vary in the case of seven tests from 2.9 to 3.9 tons per square inch, while the elongation varied from 57 to 67 per cent.

Type II.—In this case the test piece remained broad, losing sometimes only 1 per cent. in breadth, but became very thin, with a uniform reduction of thickness of about 45 per cent. The sides tended to slope slightly in the same direction away from the perpendicular. There was no necking at the fracture. The test piece remained broad, but drew down to a knife edge, and then parted in a straight line, either at right angles to the axis or inclined at some other angle to it. Tenacity values obtained in these tests varied from 2.8 to 3.3 tons per square inch, and the extension from 47 to 74 per cent.

Type III.—In this case the test piece both narrowed and thinned uniformly. There was no necking at the fracture which went straight across the test piece, as in Type II., either at right angles to the axis or inclined at some other angle. A noticeable feature of this type is the sloping of the sides so that the section after pulling is no longer a right angle, but a parallelogram, with alternate acute and obtuse angles. The sideways slipping which causes the test piece to take this form was entirely absent from Type I., and only slightly evident in Type II. It always occurs in this group, but not always to the same extent. There are greater variations in tensile properties in this than in any other group—the values for ultimate stress

* Iron and Steel Institute, May, 1923. Abstract.

ranging from 2.9 to 4.1 tons per square inch, while the extension over 3in. varies from 34 to no less than 86 per cent.

Type IV.—This combines the qualities both of Type I. and Type III., in that the test pieces not only narrowed and thinned, but, in addition, necked at the fracture. The values of tensile strength were remarkably uniform, varying from 3.1 to 3.3 tons per square inch, while the elongation ranged from 53 to 75 per cent.

Type V.—In this class are included all the test pieces which produced twin crystals on being pulled. No signs of these were visible before stress was applied. In some cases only a few resulted, while in others the test piece was twinned all over. In every case the test piece buckled and crumpled to a certain extent, owing to the shifting of portions of the sheet into a twinning position. The tenacities in this class varied from 3.0 to 3.8 tons per square inch, and the elongation from 55 to 67 per cent. on 3in.

Stress Tests of Test Pieces Consisting of Two Crystals.

Each crystal in a test piece consisting of two or more crystals behaves according to one of the five types described above, provided that the whole test piece at the point of fracture consists of a single crystal. A considerable number of specimens composed of two crystals were fractured in tension, and almost every combination of the five types was met with. In the majority of cases tested, the crystals occurred end to end in the test piece, and fracture always took place across one or other of the crystals, *but never at the boundary*. The influence of one crystal in giving support to the other at the boundary was most marked, and its effect was often noticeable at a distance of 0.25in. from the boundary. Reduction, both in thickness and breadth, was much less at this point, and the power to withstand deformation was considerably increased, especially where one crystal slipped to the left and the other to the right. The metal drew down on either side of the boundary and left it as a ridge, sometimes pronounced in thickness, at other times in breadth. In many cases the sheet looked as if it had been twisted in testing. It is not difficult, however, to account for these irregularities, when it is remembered in what different ways the single crystals extended in tension. The crystal which narrowed on pulling, in contact with the one which remained broad, tended to make the latter narrow also, with the result that it frequently wrinkled and twinned in the vicinity of the boundary. In its turn, the crystal which remained broad tended to prevent the other from narrowing, and this produced a thickening.

In those cases where two crystals existed side by side in the test piece fracture occurred across them, and one crystal frequently broke before the other. In this case, the latter crystal continued to elongate until it also broke, with the result that when the test piece was subsequently put together there was sometimes a gap of 0.25in. between the fractured halves of the first crystal.

Production of Single Crystals in Round Bars.

One inch diameter bars of the same purity as the sheet were used. Two sets of test pieces were machined from them, the diameters being 0.564in. and 0.798in. respectively. These were heated at 550 deg. Cent. for six hours and given an extension of 2 per cent. on 3in., and heat treatment as in the previous tests. This treatment was successful. On one occasion, out of eighteen test pieces, eight consisted entirely of a single crystal over the whole parallel portion. It extended up into the shoulders of the test piece, where an irregular boundary was formed. Three others were monocrystalline, except for one or more small crystals which intruded at the shoulders. As in the case of the sheet, the properties varied considerably in different specimens, the tenacities ranging from 3.0 to 4.0 tons per square inch, and the elongations from 55 to 87 per cent. in the case of single crystals.

Except that some of the crystals twinned on pulling, while others did not, there were no different types of fracture such as were found in the sheet, but the deformation of the test piece was very remarkable in all cases and deserves special mention. On the one hand, the bar consisting of small crystals drew down in the ordinary way with a roughening of the surface, a cup-and-cone fracture, and the maintenance of a circular cross-section. On the other hand, the single crystals flattened very much in one dimension, whereas the other dimension differed but little from the original diameter of the bar. Diagram I. shows (1) a section of the original bar, (2) a section after pulling so as to cause considerable distortion, and (3) a section at the fracture. The end result was not a cup-and-cone fracture at all, but what may be described as a double groove. The method of fracture was very peculiar. When the bar began to break, it drew down sharply in the same direction in which it thinned, and a

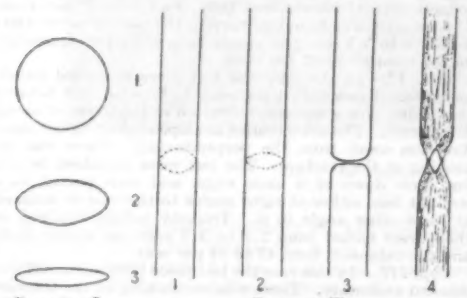


Diagram I. Diagram II.

"The Engineer" Swain Sc.

lens-shaped area was formed—Diagram II., Fig. 1. As the bar pulled apart this became smaller and smaller—Fig. 2. It parted first at each side, and then in the middle—Fig. 3. A section cut through the fracture illustrates the thinning at right angles to the plane, depicted in Figs. 1, 2 and 3, and shows the curious double-grooved fracture with flow lines, which was always obtained—Fig. 4. This type of fracture was found in all the bars where fracture actually occurred across single crystals.

Considerably more difficulty was experienced in converting the crystals in the 0.798in. diameter bar into a single crystal. After several attempts, however, bars were obtained in which single crystals extended over the entire cross section. In one case the whole of the parallel portion of the test piece was found to consist of one single crystal, while in several others more than three-quarters of the parallel portion was thus occupied. Many of the bars consisted of two crystals, but in the majority of cases these existed side by side and not end to end, so that fracture always occurred across both of them. Most of these bars twinned on pulling, so that the fracture was often uneven and did not show the definite shape obtained in the 0.564in. diameter bars. In addition to the above, 1in. square bars were treated. Owing to the shape, however, these failed to strain uniformly, and on heating crystals grew from the four corners and met in a line in the middle of the four sides. Attempts were made to measure the Brinell hardness number on two adjacent sides of the same crystals. The lowest available load, however, was 500 kilos., and the depression made was so large, owing to the softness of the metal, that it could not be made on one side without affecting the other. It was, however, possible to make depressions in some crystals which were sufficiently near the centre of the bar to obviate all risk of being affected by the edges. These were not round, as is the case with metal consisting of small crystals. Most of them were almost square with rounded corners, but they differed from crystal to crystal, according to the orientation.

When, as in certain cases, the pieces broken in the tensile tests were heated, recrystallisation was brought about. The temperature at which this began, and the size of the new crystals produced, depended on the amount of deformation of each particular crystal. Those which had been least deformed produced the largest new crystals. It was always found that the new crystals grew from the region of maximum stress, *e.g.*, from the fracture itself, from scratches on the surface, and from crystal or twin boundaries. On heating a broken single crystal, the smallest of the new crystals are found at the fracture, and the size increases up to the shoulders, where the stress has been least.

Ever since these single crystals became available, it has been the author's wish that as many of their properties as possible should be determined. Foremost among these come the elastic constants. With regard to these, the co-operation of Professor Dalby, of the City and Guilds Engineering College, Imperial College of Science and Technology, and of Dr. Stanton at the National Physical Laboratory, has been of great assistance. With their assistance, Young's modulus of elasticity and the limits of proportionality of a number of single crystals under tensile stress, have been determined and compared with those of the aggregates of small crystals—150 to the linear inch—contained in bars as ordinarily prepared. In addition, Dr. Stanton and Mr. Gough have ascertained the fatigue limits of some of our single crystals and compared them with those of aggregates. It is hoped shortly to publish these results, but it may be said they indicate that the single crystals are not isotropic, and that the properties vary according to the orientation of the crystal.

Miss Elam and the author have carried out compression tests on both round and square bars, in order to ascertain whether large crystals can be produced after deformation by compression, followed by heat treatment. It is clear from these tests that the capacity of aluminium to form large crystals is not the result of tensile strain *per se*, but is the result of strain generally.

The very high figures of percentage elongation obtained when some of the single crystal test pieces were broken in tension showed that the metal in this form was extremely ductile, far more so than when the test piece consisted of the usual number of small crystals—about 3,500,000 per cubic inch. This has been confirmed by experiments on rolling and drawing single crystals. In a given case, a crystal was rolled down from the original thickness—4in. by 1in. by 0.125in. At a certain stage, when it had elongated considerably, it was cut in half, and one of the pieces was rolled down to 0.0094in., corresponding to a reduction in thickness of 93 per cent. This rolling was done without any annealing. The strip was still quite malleable, and the operation could have been continued further had the rolls permitted it. This malleability is far in excess of that in the sheet consisting of small crystals.

Wire drawing is an extremely severe form of mechanical work, and experiments with single crystals showed that these could be drawn from a diameter of 0.564in. to 0.02in. and still remain very ductile. In order to obtain a sufficient length of bar for this purpose, test pieces 16in. long were prepared with a parallel portion of 6in.—diameter, 0.564in. Five such bars were completely converted into a single crystal over the parallel portion. In a given case, a test piece was machined 3.5in. long and 0.4in. in diameter. This was drawn down cold to a length of about 112ft. After this process, it was still sufficiently ductile to pass the Post Office test for aluminium wire. Further experiments are being carried out to ascertain the extent of the hardening during the wire drawing of single crystals, and comparing it with that of a bar containing the ordinary number of small crystals. In any case, it seems clear that the single crystals of aluminium possess remarkably high malleability and ductility in the cold, and that use might well be made of these properties in manufacturing operations.

It can hardly be doubted that the method developed by us of producing very large crystals of aluminium by a combination of mechanical strain and heat treatment is capable of extension to other metals, and, indeed, during the last two years, Miss Elam and I have been working on the metals iron, copper and silver with this end in view. It is well known that iron can be obtained in the coarsely crystalline condition. The large crystals obtained in the close annealing of mild steel sheets, and investigated by Dr. Stead, are a case in point. These sheets, after being worked, are heat treated at about 800 deg. Cent. The combination of the mechanical strain and heat treatment results in the production of very coarse crystals. Wire rope, which has been severely strained and subsequently heated, is liable to be converted into an envelope composed of very coarse crystals containing a core of small crystals. Sauveur produced coarse crystals by a combination of Brinell ball impressions and heat treatment. All these are special instances of a suitable combination of strain and heat treatment. We have carried out some preliminary experiments on iron with the object of obtaining monocrystalline test pieces. We have found here, as with aluminium, that the condition of the surface of the metal is of great importance, and that the scale present on iron and very mild steel militates decidedly against success. There is a further complication, due to the limit of heat treatment imposed by the α to γ change, at about 900 deg. Cent. Quite clearly, if it is desired to produce monocrystalline test pieces of α iron, the temperature must not exceed that of the α range.

With regard to copper, we have attained a certain degree of success in the production of coarse crystals, but the streaks of cuprous oxide present in commercial copper are a very great hindrance to the coalescence of the small crystals which have been strained and heated. Accordingly, we have obtained samples of electrolytic copper sheet rolled direct from the cathode metal, which are quite free from oxide, and will prove, we hope, suitable for experiments with this metal. Copper, however, shows a complication to which aluminium is much less liable, though it is not entirely free from it, viz., the tendency to form large numbers of twin crystals when the strained metal is heated. This undoubtedly is going to be a difficulty in the production of monocrystalline test pieces of this metal. Up to the present we have attained more success with silver than with either iron or copper. We have been able to produce crystals of this metal up to ½in. diameter and ¼in. thickness. Silver can be obtained in a state of high purity and contains no film of oxide, but it shares with copper the tendency to form twin crystals when strained and subsequently heated. I hope before long that Miss Elam and I will be in a position to publish definite experimental results with these metals.

An Efficient Pumping Plant.

In the year 1918 a set of electrically driven three-throw pumps was erected in the works of the Leeds Forge Company by Hathorn, Davey and Co., Limited, of Leeds. The plant, which has, so we understand, been ever since doing regular duty against a pressure of some 920 lb. per square inch, was, a few weeks ago, subjected to a careful test by Dr. W. T. David, M. Inst. C.E., who is, as our readers are aware, Professor of Engineering at the University of Leeds.

A copy of Dr. David's report on the test lies before us, and it will, we think, be of interest to our readers if we give a *résumé* of it. It appears that the pump, which is of the horizontal type, is driven through double helical gearing by a British Westinghouse two-phase, 50-period, 2000-volt, 300 brake horse-power induction motor, running at 420 revolutions per minute. The diameters of the three rams measured at the time of the test were 6.478in., 6.493in. and 6.496in. respectively, and the stroke of all three was 15in. The rated speed of the pumps, which were designed to deliver 300 gallons of water per minute against a pressure of 1000 lb. per square inch, is 60 revolutions per minute.

Tests were made of the unit as a whole and of the motor separately. The water pumped was measured by means of floats and staffs in two tanks of known dimensions, which had a useful range of 10,000 gallons. The pressures were measured both on the suction and delivery sides of the pump on calibrated gauges. The pump speed, which is reported to have been extremely steady, was taken by counter. The electrical measurements were made by indicating instruments—ammeters, voltmeters and watt meters—in each phase, these instruments being subsequently checked by calibration. Before the test actually commenced, the motor was warmed up and the pump run sufficiently to secure steady running conditions. The measurements of power, speed and head were taken every five minutes over a period of two hours, during which time the conditions never varied more than 2 per cent. from the mean. Measurements of delivery were taken at five-minute intervals over two periods, each of 30 min. Continuous measurement throughout was impossible, owing to the size and arrangement of the tanks.

The following results were obtained :—

Pressure head, corrected	1095 lb. per sq. in.
Suction head, corrected	6.5 lb. per sq. in.
Pressure difference	1088 lb. per sq. in.
Speed, constant throughout trial	61.4 r.p.m.
Water pumped, calculated by displacement	330 g.p.m.
Water pumped, as ascertained by measurement	330 g.p.m.
Water horse-power	251
Overall efficiency of the unit	84.3 per cent.
Motor efficiency under conditions of test	92.2 per cent.
Brake horse-power	274.5
Efficiency of pump and reduction gearing	91.3 per cent.

In commenting on these results, Dr. David adds that during the test the running of the unit was smooth and quiet; the brasses did not warm unduly, and there was no leakage past the gland. It will be noted, he adds, that the pump yielded the remarkably high efficiency of 91.3 per cent., "an efficiency all the more remarkable when it is realised that it includes the reduction gearing." He also draws attention to the fact that the slip was not measurable, and on this point remarks :—"The possible error in this figure amounts to 1 per cent. on account of the electrical measurements, and to 1 per cent. on account of slip. It is improbable, however, that these errors operate in the same direction, and the efficiency determined is, therefore, in all probability correct to within 1 per cent."

A preliminary report upon the investigations being carried out on iron for motor car and cycle engine cylinders is now being prepared for issue by the British Cast Iron Research Committee. A comprehensive *résumé* upon "Growth of Cylinder Irons" and "Temperature Stresses" has also been prepared for publication.

Railway Matters.

THE retirement on the 31st inst. is announced of Mr. Thomas Keeling, the engineer of the late Glasgow and South-Western Railway. Before he went to that railway he was connected with the old-established firm of Handyside, of Derby.

ACCORDING to Reuter the Victorian Railway Commissioners, having completed the electrification of the Melbourne suburban railways, are considering the substitution of electric traction for steam operation on some of the country lines.

BEFORE the war the direct route from Calais and Boulogne to Basle was *viâ* Laon, Chalons and Belfort. But the railways in this area were so much destroyed during the war that not until now has the Laon route again been available. It was re-opened on Tuesday week, the 15th.

IT is officially announced that Mr. A. T. Blackall, M. Inst. C.E., the signal and telegraph engineer, Great Western Railway, will retire on June 14th, and will be succeeded in that position by his chief assistant, Mr. R. J. Insell. Mr. C. M. Jacoba becomes the assistant signal and telegraph engineer.

HAVING resigned his position as Canadian Minister of Defence, the Hon. George P. Graham has been appointed Minister of Railways and Canals, a post he formerly held for four years under the Laurier administration. In addition to his duties as Minister of Defence, he has been Acting Minister of Railways since the fatal illness of the late Hon. W. C. Kennedy.

THE average number of passengers using the Flinders-street, Princes Bridge and Spencer-street stations, Melbourne, during each week-day, averaged, for 1922, 285,608, and for each Sunday, 71,402. The first-named figure, during certain previous years was 164,094 in 1909, 186,667 in 1911, 231,909 in 1914, and 209,232 in 1918. The number of trains each week-day using Flinders-street and Princes Bridge Stations in 1922 was 2376 electric passenger, 38 steam passenger and 226 through goods; total, 2640 trains.

IT is announced that the Westinghouse Electric and Manufacturing Company has been awarded the contract for the electrification of the Virginian Railway between Roanoke, Va., and Mullins, W.Va., a distance of 215 miles, at a cost of 15,000,000 dollars. It is planned, so it is reported, to use electric locomotives capable of developing 20,000 horse-power per train, and to haul 9000-ton trains over the mountain gradients at 14 miles per hour. Power is to be supplied by a 90,000 horse-power steam turbine generating plant on the New River.

DURING the three months ended September 30th last, the Assistant Inspecting Officers of the Ministry of Transport considered it necessary to hold thirty-three inquiries into accidents to railway servants, of which sixteen were fatal cases, involving the death of twenty men. Of these nine were men employed on the permanent way, four of whom were killed in one accident through not obeying Rule 273 and standing clear of all lines. In another case two men were caught on a bridge and killed. They broke another clause in the same rule by not having a look-out man to protect them.

UNQUALIFIED public and professional interest is centred on the German Government's present efforts to circumvent the coal shortage by electrifying the State railways. By demonstrating the superiority in service and economic efficiency of electricity over steam, it is hoped to offset the handicap to German railway transportation resulting from the occupation of the Ruhr coal fields and the deliveries previously made under the Versailles Treaty. Not only railways, but factories, will be compelled to use electric power. Lack of coal has forced the German State Railway Administration to withdraw a large number of trains. Even now the remaining trains run principally on imported English bituminous coal. Leipzig is already the terminus of several electrified lines.

IN this column on August 19th, 1921, mention was made of a collision which had occurred on the 25th of the previous month on the Burma Railways, when the Rangoon mail, crowded as a result of some races, came into head-on collision with a goods train owing to two tokens for the same section being out together. This accident was mentioned in the annual report for 1921–22 of the Indian Railway Administration, reviewed in THE ENGINEER of the 27th ult., but it was not stated in the report what token system it was that failed. It was certainly not the electric train staff, as that method is not employed in Burma, and as since the accident some forty or fifty tablet instruments have been ordered by the Burma Railway Administration, it cannot have been the tablet. It must, therefore, have been one of the "locally designed instruments . . . made in India . . . at considerably lower cost than the English instruments" mentioned in the paper "Railway Signalling in India," by the late Mr. C. W. Hodson, read at the Institution of Civil Engineers on December 14th, 1909.

ON February 23rd, two passenger trains were in collision at the Riverside Station, Cardiff, Great Western Railway. Colonel Mount inquired into the accident and his report was issued on the 10th inst. The signalman concerned had to deal with two trains then in the station—one for Penarth and one for Barry. When the former train left the man got into his mind that he was dealing with the Barry train, and he irregularly "cleared" the latter on the branch line instrument, instead of the Penarth train on the relief line instrument. Having "cleared" the Barry train he accepted one for Pontypridd, which ran into the Barry train. Three passengers were severely and twenty-eight slightly injured. Colonel Mount, in concluding his report, said: "At a junction of this nature, where movements are particularly frequent at the peak periods of local traffic, the immunity from error of this kind is remarkable, in that there exists at Riverside Station no supplementary means—for example, track circuiting with the usual locking—of reminding the signalman in the West box of trains standing within his control." He understands that the company has this feature of the case under consideration.

Notes and Memoranda.

AN investigation made in September, 1920, by Mr. George S. Rice, Chief Mining Engineer of the American Bureau of Mines, disclosed the fact that there were 136 liquid oxygen plants in operation at coal, iron, potash and salt mines throughout Germany, having a total capacity of 3797 litres of liquid oxygen per hour. Allowing for losses, and calculating the time operated, a net total of 2,430,000 litres, or 5,346,000 lb., of oxygen was used, equal to 8,000,000 lb. of dynamite. One of the most interesting features of the development had been the design and construction of small portable liquid oxygen-making plants of a capacity of only 3 to 5 litres of liquid oxygen per hour. Such plants have been constructed for moving about on trucks, thus making liquid oxygen much more available for small operators.

DETERMINATIONS of the specific heats of T.N.T., picric acid and tetryl, have recently been made by the Department of the Interior at the explosives laboratory of the Bureau of Mines, Pittsburgh, Pa. The heat of fusions of T.N.T. was also determined. Work is now being done on the heat of fusion of picric acid, specific heat determinations being made over ranges of 1 deg. Cent. below the melting point of the substances and at room temperature, zero and —78 deg. Cent. to —182 deg. Cent. The explosions temperatures and decomposition points have been determined of mercury fulminate, cyanuric triazide, nitro-mannite, tetryl, T.N.T., picric acid and trinitroxylene, with varying rates of heating. Tests were made by dropping the material on hot metal, and by bringng the temperature up over a period of several minutes.

AMONG the recent successes of the research department of the International Nickel Company is a new nickel-silicon steel which is stated to be unusually hard and tough and to be susceptible of considerable commercial development. Nickel added to cast iron in amount from 2 to 4 per cent. has been found to increase its usefulness markedly, and a number of American foundries are experimenting with its use. The company has produced a nickel-bearing type of stainless steel said to contain from 20 to 40 per cent. of nickel, 6 to 12 per cent. of chromium, and 0.25 to 2 per cent. of silicon, which can be readily machined and fabricated. One rolled sample tested gave:—Tensile strength, 100,000 lb. per square inch; yield point, 60,000 lb.; elongation in 2in., 20 per cent.; and reduction of area, 50 per cent. Seamless nickel tubes are now available, made from malleable nickel, amenable to the process by which seamless tubes of copper and steel are produced.

THE advantages and limitation of the auto-transformer as compared to the two-winding transformer, states the *Electric Journal*, are perhaps not generally understood. The auto-transformer can only be used where it is unnecessary to insulate the secondary winding from the primary. In certain cases, it may be permissible to use an auto-transformer from the view point of voltage alone; but other undesirable conditions prevent such use. The main advantage of the auto-transformer, where it can be used, is that it is cheaper than the two-winding transformer. Since the amount of material used is less, the losses are lower and, therefore, the efficiencies are higher. The efficiencies of an auto-transformer, when based upon the amount of energy transformed, are at times almost unbelievably high. The reactance of the auto-transformer is also low, and in some applications this may become somewhat embarrassing when, for example, it is desired to have the impedance sufficiently high to withstand short-circuit conditions. The degree of lower cost, higher efficiency and lower reactance of the auto-transformer depends on the ratio of transformation.

AN Indian correspondent, writing in the *Manchester Guardian Commercial* says:—"India is rich in raw material—in things that grow. She has knowledge and power and arts and crafts, and her economic future depends on the wisdom or folly of her statesmen. Agriculture is her most vital industry, and it is here India must begin her industrial future. The production from the land could be doubled by organisation. . . . To-day there is little they can buy in the village itself. If India is to progress, we must begin with the villages. We must make the village again a self-sufficing unit, and modernise it, bringing the meaning of civilisation home to the countryside. We must bring motive power and modern implements within the reach of the villages. India is rich in resources of water power, and coal and oil are there. Every district should have its electric power stations. The ploughman in the fields, the weaver in his hut, the blacksmith in his shop must be enabled to enjoy the fruits of scientific discovery. A Royal Commission on Agriculture would serve a good purpose in bringing to the focal point the economic conditions of the villages, and suggesting ways and means to organise capital for agriculture and allied industries."

IN the course of a paper on "Calorific Value," read by Mr. W. B. Davidson, Ph.D., D.Sc., F.I.C., before the North of England Gas Managers' Association recently, the author said it was interesting to speculate as to what the town gas of the future would be. Some pinned their faith to straight coal gas; others to water gas; others, again, to mixed gas obtained by complete gasification. Undoubtedly the cheapest gas that could be manufactured was producer-gas. With reference to cost per therm, in the author's experience this gas was obtainable at less than half the cost of coal gas. The cost of its distribution, however, was generally considered to be prohibitive. Credit must be given for the much lower degree of aeration required as compared with coal gas, requiring considerably less pressure at the injector nipple of the Bunsen burner. Probably the maintenance of a higher general pressure in the mains with governors on each service-pipe would overcome any difficulty of supply. Producer gas had a comparatively low flame temperature, which had a prejudicial effect on incandescent lighting and the radiation of a gas fire, though scarcely affecting other domestic uses. Some of them were looking to the introduction of cheap oxygen on a large scale for the toning-up of producer gas into a thoroughly satisfactory gas which would satisfy all demands as regards price and efficiency.

Miscellanea.

THE New York correspondent of the *Times* states that Lieuts. Macready and Kelly completed a non-stop aeroplane flight across the United States from New York to San Diego on May 3rd. The distance traversed was approximately 2600 miles, and the time is given as 26 h. 50 min. 38⅘ sec.

IN reply to the Town Clerk of Aylesbury the Ministry of Health states that it is not contemplated that any regulations should be issued by the Ministry with regard to the installation of wireless sets and the fixing of aerials at houses erected under the Assisted Housing Scheme, and that the question of conditions upon which permission to install such sets should be granted is a matter for the decision of the local authority.

A SERIES of tests of gas masks and respirators was recently made in the Knobley tunnel of the Western Maryland Railway at Baltimore by representatives of that railway and the Bureau of Mines of the Department of the Interior. The low resistance of pocket respirators manufactured commercially was found to give good protection against dense smoke and irritating gases from a heavy freight locomotive.

THE British Electrical and Allied Manufacturers' Association calls attention to the fact that, in furtherance of technical education, it grants annually, to properly qualified candidates of British birth and engaged in engineering works, ten scholarships each of £100, in addition to the payment of college fees. Applications by June 1st. Particulars may be obtained by writing to the Secretary, B.E.A.M.A., 36, Kingsway, London, W.C. 2.

THE Air Ministry announces that the Royal Air Force pageant, which was instituted in 1920, will take place on Saturday, June 30th, at the London Aerodrome, Hendon, by arrangement with the Grahame White Company. It is hoped that the King will be present. The pageant now affords the general public an annual opportunity of observing developments both on the flying and technical sides of the work of the Royal Air Force.

IN order to stimulate interest in China in matters electrical, the Hankow branch of the General Electric Company has fitted up a Chinese houseboat as a travelling showroom, and is sending it forth on a long trip up the Han River. The boat is fitted with one of the company's country house lighting sets, consisting of oil engine, dynamo and switchboard, and the boat will make a stop at every Chinese town passed during the journey, and demonstrations will be given. A plenteous supply of advertisements and pamphlets, printed in Chinese, are being taken on the journey.

UP to the present the shipbreaking industry in Germany has been very prosperous, the end of the war and the Washington Disarmament Convention having brought a large number of old warships into Germany to be broken up. The Wilhelmshaven shipbreaking yards had developed considerably, and twenty-five other yards produce some 40,000 tons of scrap iron and steel a month. The prosperity of these yards is now greatly waning, and a certain number of them have been transformed into shipbuilding yards, the breaking-up of old merchant ships being less profitable than that of war vessels.

THE Department of Scientific and Industrial Research has turned its attention to the deterioration of stonework in buildings, particularly historical buildings and ancient monuments which, owing to the ravages of the weather, show signs of serious decay and the gradual demolition of their tooled surfaces. A special committee of the Building Research Board has been appointed to report on the best methods of preventing and arresting such decay. Sir Aston Webb, the President of the Royal Academy, is the chairman, and the address of the secretary will be 16, Old Queen-street, London, S.W. 1.

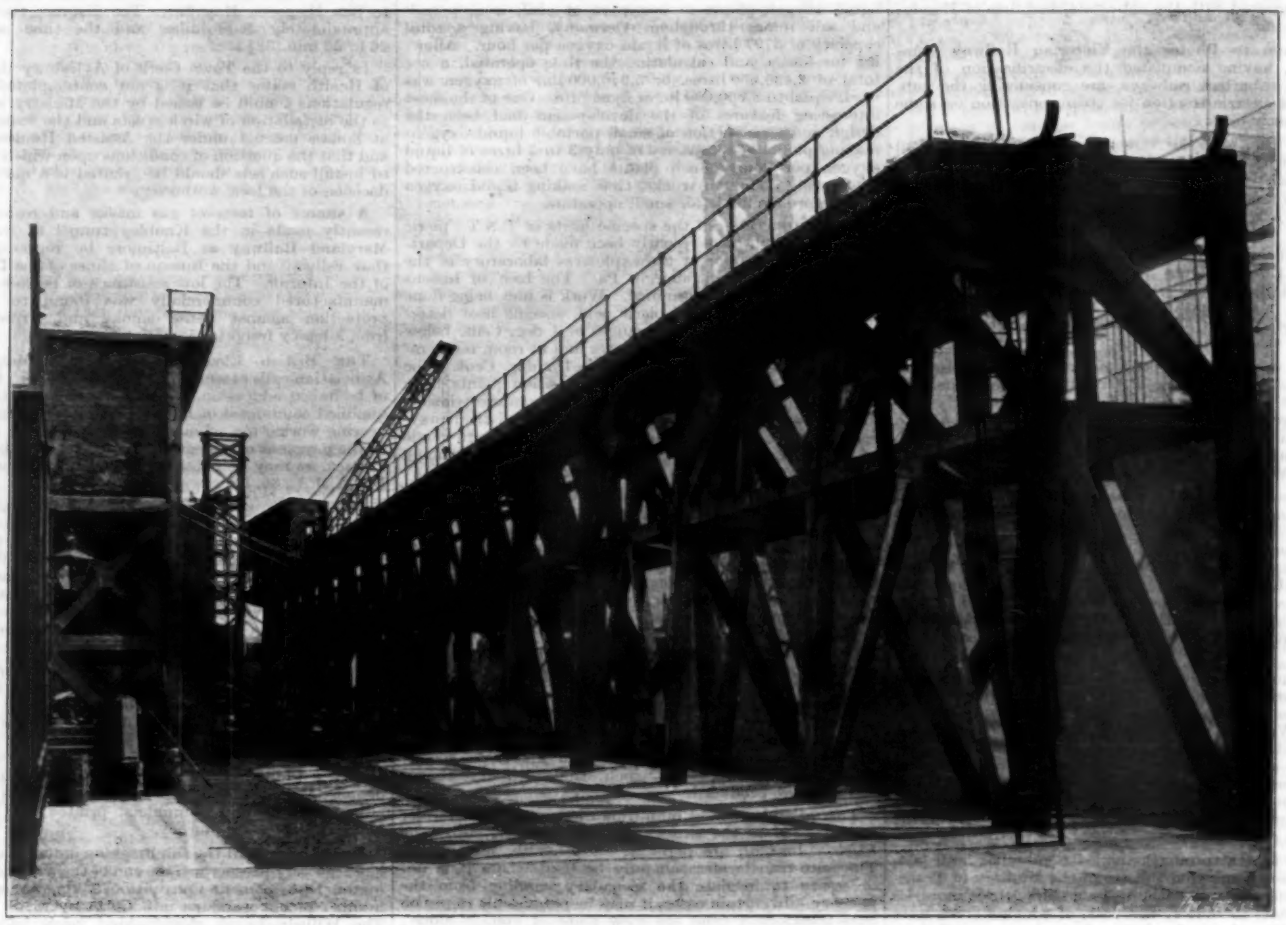
THE Official Secretary in London of the Commonwealth of Australia states that the Australian Customs Department has issued a series of tariff decisions relating to duties on wireless apparatus. Fixed and variable condensers, crystal and electrolytic detectors, rheostats, inductance coils—honeycomb and coupled coils—inter-valve transformers, valve sockets, and complete tuning sets, will be charged 27½ per cent. under the British preferential tariff, 35 per cent. under the intermediate tariff, and 40 per cent. under the general tariff. Valves will be free under the British preferential tariff, 5 per cent. under the intermediate tariff, and 15 per cent. under the general tariff.

ON April 1st of last year the number of broadcasting stations in operation in the United States numbered only 137. This meant that there were large areas in the country where broadcasting could be received only from stations at a great distance. The situation now, however, is much different, there being over 500 broadcasting stations licensed at the present time. These stations are so well distributed over the whole country that there is no place, with the exception of one point in the south-western section, which is farther than 150 miles from a good broadcasting station. In fact, about nine-tenths of the area of the country, and probably 95 per cent. of the population is within 100 miles of a broadcasting station which furnishes an excellent service.

DEPOSITS of iron ore, said to be identical in quality with those of Krivoi Rog and not inferior in quantity to those in the Donets region, are reported to have been discovered in the province of Kursk. M. Krassin, the Soviet Envoy, now in London, is quoted as the authority for a statement that the Soviet Government, impressed by the prospects of the deposits, organised an investigation by experts, whose report, recently submitted at Moscow, is described as a highly favourable one. A sample of magnetic iron ore, containing 70 per cent. of iron and obtained at a depth of 500ft. by diamond boring, is said to have been exhibited, and it is understood that further exploration is to be undertaken. A fact not without significance in this connection is that during and since the negotiations at Brest, German capitalists have made persistent efforts to secure a concession for the working and development of the deposits, but that their requests have hitherto been categorically refused.

NEW GASWORKS AT CARLISLE

(*For description see page 541*)



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By arrangement with Reuter's Engineering Service, **The Engineer** *contains the latest news from all parts of the world which is likely to be of interest to engineers.*

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THE ENGINEER.

MAY 25, 1923.

The Mechanical Properties of Metallic Crystals.

IN the study of strength and elasticity in metals we have to deal with the properties of a mass of crystals promiscuously arranged and bound together by friction or attraction or, as many suppose, by an amorphous intercrystalline cement formed from the molecules which escape crystallisation when the metal is cooling. The fundamental complexity of the material system which constitutes a metal will thus be recognised, more especially when it is stated that the number of crystals in a cubic inch of normal metal varies from about three million to nearly seven million, while it may be as much as 125 thousand million in severely drawn wires of certain metals, such as molybdenum. In these circumstances it is natural to suppose that what we call the strength of a metal is the resultant as much of the relationship of the crystals among themselves as of the intrinsic chemical nature of the crystalline molecules. Experience confirms this view. For example, heat treatment with its marked effect on the strength and elasticity of metals alters the crystalline structure without affecting the chemical composition. But while we may be certain that crystalline structure plays a most important part in the matter, it has hitherto been impossible even to guess how much the strength of a metal is affected by it, and how much by the nature of the individual crystals themselves. A considerable, although by no means full, light has now been thrown on this subject by Professor Carpenter, who, together with Miss Elam, has succeeded in preparing and testing relatively enormous single crystals of aluminium. As recorded in the paper in which Professor Carpenter presented his results before the Iron and Steel Institute, a *précis* of which will be found elsewhere in this issue, similar efforts to prepare mono-crystalline specimens of iron, copper and silver have not so far met with equal success. Until comparable data for these and other common metals are available it will, of course, be dangerous to draw any rigid deductions from the observations made with the aluminium specimens. Sufficient, however, has been done to show that a new method has been opened up for attacking some of the most fundamental problems in crystallography, metallurgy and elasticity, and to warrant some cautious speculation as to the general significance to the engineer of the results established.

The specimens prepared and tested by Professor Carpenter consisted either of flat plates ½in. thick, 1in. wide and 4in. long between the shoulders, or of cylinders 0.564in. or, in some cases, 0.798in. in diameter and 3in. gauge length. By means of a certain treatment, the rationale of which has been satisfactorily established, consisting of an application of tensile or compressive stress followed by an application of heat, the normal crystalline structure of the specimens can be developed out of all recognition until the million or two original crystals coalesce or become absorbed in one occupying the full length, breadth and thickness of the specimens. The specimens thus prepared were tested in tension and were found to yield results in interesting and significant variance from those obtained from aluminium in the normal state. In the case of the flat plate specimens the manner in which fracture occurred and the stress required to produce fracture varied in a very remarkable manner. Out of a total of forty-three specimens tested seven broke by drawing down to a neck breadthwise, while the thickness showed little or no reduction. An equal number, on the other hand, failed in exactly the opposite way, namely, by drawing down to a chisel edge, while the breadth remained substantially unaltered. In fifteen other cases failure occurred by a uniform narrowing and thinning of the specimens throughout their lengths, and in eight instances fracture ensued similarly, except that the narrowing was not uniform, but marked by a neck. Finally, in five cases the test pieces buckled and crumpled consequent upon the original single crystal twinning under the applied stress. As compared with a tensile strength of 4.5 to 4.7 tons per square inch for normal aluminium, these mono-crystalline specimens showed strengths ranging from 2.8 to 4.1 tons, while against a normal elongation of 36 to 38 per cent. they indicated an elongation ranging from 34 to 86 per cent. The cylindrical specimens fractured in a uniform manner, except that in some cases the crystals twinned when pulled. The general method of fracture consisted of a reduction of the diameter in one direction, while the diameter at right angles remained practically at its original value. This form of rupture is at total variance with that normally observed in a cylindrical specimen in which the section at fracture remains circular. The tenacities of the cylindrical mono-crystalline specimens again showed a reduction, being from 3.0 to 4.0 tons, as compared with 4.82 to 4.88 tons for normal cylindrical specimens, while the elongation showed the same marked increase as in the flat specimens, ranging from 55 to 87 per cent. All these results may appear confusing and as having little coherence, but on examination and study they are capable, we think, of being brought within a simple general explanation. It is apparent that the crystals of aluminium in the large size "grown" by Professor Carpenter are not isotropic, that their properties differ according as they are tested in different directions relatively to the crystalline axes. While Professor Carpenter can exercise control over the formation of the crystals, he cannot apparently control the orientation of their axes relatively to the boundaries of the test pieces. Hence in the flat plate specimens the variations in the recorded tenacities and in the method of fracture are simply reflections of the non-isotropism of the crystals and of the fact that the principal axes are not all set uniformly relatively to the geometrical axes of the test pieces. It is a little difficult to perceive on this theory why the cylindrical specimens, except where twinning occurred, fractured in a uniform manner. We would suggest as a very probable explanation that the symmetry of the cylindrical section encourages the growth of the crystal with its axes arranged in constant directions, while in the flat plate pieces the orientation of the crystalline axes is affected capriciously by the asymmetrical form of the section.

Whatever may be the correct scientific explanation of the results, it seems certain that they are bound to have an important practical interest. The figures for elongation appear at present to be the most striking in this respect. Scientifically, we may wonder why tenacity and elongation should be affected oppositely by the crystalline structure, why the division of the metal into several million minute crystals should enhance the tensile strength, whereas their aggregation into one immense crystal greatly increases the elongation which the metal may sustain before rupture occurs. From the practical standpoint the augmented elongation is of significance by reason of its bearing upon the ductility of the metal and the workshop operations in which that property is involved. One obvious application is in connection with wire drawing. Professor Carpenter has studied this point and has found that a mono-crystalline specimen 3.5in. long and 0.4in. in diameter can be drawn down in the cold and without annealing to a length of 112ft. and at the end remain sufficiently ductile to pass the Post Office test for aluminium. In

another instance a flat strip specimen was reduced without annealing 93 per cent.—the limit imposed by the rolls employed—and still remained quite malleable. It cannot, of course, be prophesied that results of equal magnitude will be obtainable with other metals, but it would appear reasonable to hope that they will exhibit, when prepared in mono-crystalline specimens, a change of properties of an equally interesting nature. If so, then it seems to us that, alike from the purely scientific and from the purely practical point of view, Professor Carpenter's investigations will be found to contain an active promise of great developments in our understanding and control of metals.

What Science Owes to the Engineer.

It is an interesting coincidence that a few days after the publication of a leading article in THE ENGINEER—May 11th—in which the dependence of science upon engineering was insisted upon, an article should appear in a daily paper—the *Morning Post* of May 19th—from the pen of an eminent Fellow of the Royal Society, who makes and reinforces the same point. The article, written by Sir Napier Shaw, the famous meteorologist, is full of admirable sense wittily expressed. It gives us the impression that the author, in quite a good-humoured way, is rather put out because abstract science has to look to "base mechanics" for its furtherance. But Sir Napier skilfully turns that fact to advantage by proclaiming the desirability of the union of science and the engineer at the great exhibition of 1924. "Here," he exclaims, "in this greatest all-British exhibition ever held, is an opportunity for showing to our fellow-subjects overseas that the British workshop and British science have still the same ideals and the capacity for expressing them."

But we are less concerned with what Sir Napier Shaw says by way of propaganda for the Empire Exhibition than we are with his remarks upon the value of engineering to science. "It was once noted by a wise man," he writes, "that the great development of the physical science in the nineteenth century was due to the invention of the sewing machine; not on account of any direct connection between sewing and science, but because science required for the manufacture of its apparatus the same tools for 'small work' as those which had been originally designed on the commercial scale for sewing machines." That is, perhaps, rather too wide a cast, for by the same method we might argue that science is dependent upon tailors, since the history of all nations shows that knowledge is more advanced in those that wear clothes than in those that do not. Teufelsdrück would no doubt have reached from that fact the deduction that science hangs upon a clothes-peg. Our author is more precise, more to the point when he observes, despite a rather obscure *sequitur*, that "If it be true that an army crawls upon its belly, it is just as true that progress in physical science is conditioned by its workshop." Yet even that does not wholly satisfy us, for we would not have it believed that the engineer is no more than a mechanic doing the bidding of the scientist. His influence upon abstract science goes far deeper than that, and our author "gets warmer" when he writes that "The number of facts that have been added to knowledge by sheer thinking or by mathematical reasoning is so few that the leading cases are known of all men"—in other words, abstract science is generally preceded by concrete deeds. Events, it seems to us, take one of two courses. A scientist wrings from Nature some fact—as, for example, that the atmosphere has weight. The engineer turns it to practical account, as in the steam engine, and passes it back again to the scientist for further development. On the other course the engineer starts doing something in his blundering sort of way—as, for example, the propulsion of ships by steam—and then the scientist gets to work and shows him why he is able to do it, how he may improve upon his method, and what his limitations are. The second course is far more crowded than the first. Nearly the whole progress of the mechanical arts up to the introduction of the electrical machine was due to the purely practical efforts of ignorant mechanics. It is here that we see most plainly what science owes to engineering. The heat engine came before Carnot, and without it we should not have had his masterly generalisations with which the science of thermodynamics began. Fulton came before Froude, and without him the science of the resistance of ship-shaped bodies would not have been developed. Roberts, Nasmyth and Maudslay advanced the art of cutting metals, and without them the science of that craft would never have been thought of; Tubal Cain founded the practice of metal working upon which there has been built up the beautiful scientific metallurgy of to-day. Some may be tempted to retort that the sequence is a natural and obvious one; that the "science" could not exist till there was something for it to practise upon; that there would have been no need for it. If they do we shall thank them for admitting so readily that, in such cases, science has been built up upon an engineering foundation. Yet we may claim that a Carnot before heat engines is conceivable, and that a science of thermodynamics might have paved the way towards the work of Savery, Newcomen, Watt, and all their successors, just as the discoveries of Faraday opened the gateway through which electrical engineering has passed. In the vast field of civil engineering the dependence of science upon the engineer is seen at every turn. Without him the science of sanitation would have remained where it was in the Middle Ages, and the science of pure water would have been no more than the pastime of chemical laboratories. The science of modern agriculture has sprung from the ability of the engineer to increase the fertility of soils by irrigation and drainage and by the supply of artificial manures. Without him it would have remained in Europe as it still is in a great part of the East, dependent wholly upon the will of a despotic Providence.

We have not dwelt again upon the direct and obvious utility of engineering to Science through the provision of the materials, the machines, and the power which it employs, and without which it would have been condemned to the "pure thinking" of Greek philosophers and could never have entered upon the era of practical research. On this occasion we prefer rather to make the point that engineering, by demanding the services of science, has enormously increased our store of exact knowledge and has incalculably increased man's means for thinking logically and his ability to do so. The intellectual good that it has thus done would require for just treatment the pen of a scientific Lecky or Draper. We see in it the groundwork for a new History of Intellectual Progress in which the influence of engineering upon scientific thought would be exhibited and in which the development of human intelligence through the works of the engineer would be made manifest. A troubled and confused history perchance, but an instructive one. Full, indeed, of the lust of money and the pursuit of cheapness, reeking with the sweat of labour and a thousand hardships, marked by the destruction of beauty, the coming of noise and dirt, and the uprising of new factors in human contention, but making, in the long run, as we earnestly believe, for greater good. Springing from the toil and storm of the factory, Science moves upon its even way, bringing new intellectual enjoyments to those who merit them, and raising the general body of the people, despite itself and despite many apparently retrograde steps to a better level. Without the engineer, without the factory, physical science would have remained the privilege of the few; with them it is expanded, world-wide, through the training of young men in our colleges, and the ever extending familiarity of the public with the products of the engineer and the scientist.

Literature.

Jane's Fighting Ships, 1922. Edited by Dr. OSCAR PARKES. Sampson Low, Marston and Co., Limited. £2 2s. net.

In spite of post-war demobilisation and the wholesale scrapping of naval tonnage under the Washington agreement, sea power still remains a primary factor in world affairs. Compared with the gigantic armadas of the war period the fighting fleets of to-day seem almost insignificant, but they consist for the most part of extremely powerful units, embodying the experience gained during the greatest sea campaign in history. Contrary to expectation, public interest in naval affairs has been well maintained since the war.

First came the discussion on the utility of the great ship, revealing a marked divergence of expert opinion, but tending, on the whole, to vindicate the judgment of the Admiralty in holding to the capital ship as the supreme element of battle power. Then followed the Washington Conference, at which whole fleets were abolished by a stroke of the pen, and the five leading navies of the world were bound down to a fixed scale of relative strength for a space of ten years. More recently we have witnessed an exchange of views between this country and the United States on the technical question of gun range, and now there is talk of a second international conference to bring all the lesser types of naval craft within the scope of the limitation Treaty. Any publication which throws light on these and kindred topics is, therefore, assured of a welcome, especially when it is so old and valued a friend as "Jane's Fighting Ships."

The present issue was prepared, we understand, under circumstances of unusual difficulty. For some years past the volume has been jointly edited by Mr. Maurice Prendergast and Dr. Oscar Parkes, in whose able hands it acquired a high reputation for reliability. Last summer, however, Mr. Prendergast was overtaken by ill-health, and the task of making up the book and seeing it through the press accordingly devolved almost wholly upon his colleague, Dr. Parkes. Nevertheless, the standard of quality has been well maintained, and the new volume is in some respects an advance on its predecessors. A reduction has been effected both in size and cost by ruthlessly deleting non-essential details. The memoirs on naval policy, administration, &c., introduced as a new feature last year, have now been discarded, together with the plans of dockyards and fleet bases. Space has also been saved by revising the classification of smaller vessels and bringing them within a narrower compass, this system being seen to special advantage in the case of the United States destroyer flotilla. On the other hand, the practice of devoting large blocks to the principal ships of each navy has been extended, many of the Dreadnought illustrations in the British and American sections being fine specimens of the marine photographer's art. The British silhouettes have been re-drawn and reproduced on a large scale, which renders their identification easy to the trained eye. The ships' data in all sections bear traces of careful revision, in some cases by the Admiralties concerned. Details of new construction are as complete as possible, but it is obvious from the blanks which occur here and there that the various Governments are not always disposed to impart advance information concerning their latest designs. Reticence is displayed by our own authorities with regard to the new battleships now being built. A very large number of new and up-to-date photographs are reproduced in this issue, some remarkably fine views being given of the latest American and Japanese ships. To facilitate recognition from above, aircraft views of the more important vessels have been inserted.

The backbone of the British Navy to-day consists of the ten fine battleships completed since 1914, of which five belong to the "Queen Elizabeth" and five to the "Royal Sovereign" class. Save for a slight difference in speed they constitute a tactical unit of unexampled homogeneity and power. In the second line we have the eight ships of the "King George V." and "Iron Duke" classes, whose fighting value still ranks high. There is also a battle-cruiser squadron of four ships, led by the Hood. Three of these vessels can attain the remarkable speed of 31 knots. All available details of the new aircraft carriers Hermes and Eagle will be found in the British section, together with drawings of them as they will appear at sea. Adequate space is devoted to the Dominion fleets, and we notice in the Australian pages a photograph of the light cruiser Adelaide, built at Sydney dockyard and completed last year. Another view shows the fleet collier Biloela, said to be the first naval vessel built entirely of Australian material and from Australian designs. The other navies are now arranged in alphabetical sequence, which is a distinct improvement over the old system of grouping them in order of importance. There are good illustrations of the ex-German warships now serving under the French and Italian flags; the French battleships which have undergone big refits since the war are seen in their new rig, and views are given of nearly all the minor craft which have been added to the various navies, great and small, since the last issue.

"Jane's Fighting Ships" is so well known to naval officers and others interested in naval affairs that it would be superfluous to comment on those qualities which have made it unique among the works of reference dealing with this subject. Although reduced in bulk the present volume is rich in descriptive and pictorial matter, the make-up is excellent, and the price reasonable.

BOOKS RECEIVED.

Trade Unionism and Munitions. By G. D. H. Cole. Oxford: The Clarendon Press.

Pioneer Railway Engineering. By H. Stringer. London: H. F. and G. Witherby, 326, High Holborn, W.C. 1. Price 12s. 6d. net.

Transactions of the Liverpool Engineering Society. Vol. XLIII. Liverpool: Published by the Society, Royal Institution, Colquitt-street.

Costing and Price Fixing. By J. M. Scott-Maxwell. London: Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, W.C. 2. Price 6s.

A Practical Treatise on Suspension Bridges. By D. B. Steinman. London: Chapman and Hall, Limited, 11, Henrietta-street, W.C. 2. Price 20s. net.

The Empire Municipal Directory and Year Book, 1923–24. London: *Municipal Engineering and The Sanitary Record*, 8, Breams-buildings, E.C. 4. Price 10s. 6d. net.

Mahaffy and Dodson's Law relating to Motor Cars. Second edition. By C. S. Rewcastle. London: Butterworth and Co., Bell-yard, Temple Bar, W.C. 2. Price 22s. 6d. net.

The Gas Turbine in Theory and Practice.

No. IV.*

In our last article we pointed out how the successful operation of a gas turbine, apart from questions of mechanical construction, depended primarily on :—

(i.) The ratio of positive to negative work in the cycle employed, and

(ii.) the efficiency of compression and expansion,

and for the constant-pressure super-atmospheric cycle single fluid machine it was shown that with a two-row velocity compounded turbine of 65 per cent. efficiency, the ideal brake efficiency, even with an initial pressure of 500 lb. per square inch pressure, would not exceed 19.6 if the compression were adiabatic and the compressor had an efficiency of 90 per cent., or 23.2 if the compression were isothermal and the efficiency reached 70 per cent. These brake efficiencies are capable of considerable improvement on the air-cycle used, but when dealing with the real working fluid the absolute thermal efficiency is adversely affected by the variation in the specific heat of the substance, and in the following article it is proposed to indicate the tendencies caused by the variation of cycle limits from those given in Table III., as well as to show the directions in which the overall efficiency of turbine and compressor may be improved.

Before doing this, however, it is necessary to devote a brief space to a consideration of the thermal efficiencies actually obtained with existing types of prime mover. In the best marine work, an overall efficiency of engine and boiler exceeding 16 per cent. is very rare. In the best power-stations of large size, a test efficiency exceeding 20 per cent. is quite exceptional. Table VIII. gives a number of typical efficiencies. In large steam work probably the best thermal efficiencies and efficiency ratios recorded are those obtained from large Parsons two-cylinder units, of which the following are typical :—

Installation.	Output of machine, kilowatts.	Thermal efficiency of turbine.	Thermo-dynamic efficiency (steam before stop valve).
Lots-road, Chelsea	15,000	23.31	71.8
Commonwealth Edison, Chicago	25,000	25.29	77.3
Carville	10,000	25.41	73.1
Dunston	12,000	24.67	75.2
Mean		24.67	74.35

A very good result for a small station was reported in THE ENGINEER on December 15th last ; a Brush-Ljungström 5000-kilowatt turbine installed at the Birchills station, Wallsall, showed a consumption of 19,500 B.Th.U. per kilowatt, the thermal efficiency ratio of the turbine being 78.5 per cent., and the thermal efficiency of the whole station 17.49 per cent. on a six-hour trial. In large power station work, the steam cycle limits have been increased from an adiabatic heat drop of about 390 B.Th.U. to about 480 in recent years, the latter involving 300 lb. pressure, 300 deg. Fah. superheat and 97 per cent. of normal barometer vacuum, and offering a gain in absolute thermal efficiency of between 20 and 25 per cent. over the conditions of ten or fifteen years ago. The best brake thermal efficiency recorded is very little over 20 per cent. *on short trials* ; the yearly working average at Carville fell to nearly 15 per cent. below the test value. A brake efficiency of 24.4, or only 14,000 B.Th.U. per kilowatt-hour, has been quoted as obtainable, but it is doubtful if this would amount to more than 20–21 per cent. in service and could, in any case, only be reached under conditions of an exceptionally favourable nature. It pre-supposes a turbine efficiency of 28 per cent., coupled with a boiler efficiency of 87 per cent., or an improvement of, say, 12 per cent., in the one, and 4 to 5 per cent. in the other over all previous records, and the former, at least, could only be obtained with very large units and further increase of pressure and temperature. It does not pay to extend these so far with small or medium size plants. The somewhat low figures for efficiency reported by the Electricity Commissioners for 1920–21 are quite explicable in view of the character of the plants, but it must be remembered that the first three are reputedly modern in most respects.

Under general working conditions it is the boiler plant which so greatly reduces the overall efficiency from the figures obtained on trial, and for small plants Mr. Brownlie's recent paper showed a wide-spread degree of inefficiency that was almost amazing. The upper limit of boiler efficiency obtainable with feed heaters, superheaters, economisers, and air heating, might be taken as 85 per cent.; experience proves that 70 per cent. is seldom exceeded in yearly service. It is this handicap on the steam turbine which gives the internal combustion turbine its opportunity.

For the year ending March 31st, 1922, the Electricity Commissioners' report, just issued, is cast in slightly different form to the previous one, on which the figures in Table VIII. are based. Of the 396 stations using steam, the average fuel consumption per unit generated was 3.11 lb., and the lowest at any station was 1.70, or 2.32 lb. and 1.27 lb. respectively per brake horse-power. The best thermal efficiency was 17.2 per cent., as against 17.75 last year, and that of the station with 1.70 lb. was 16.5 per cent., which was the second best recorded. The average of the best five stations in large groups was 15.7 per cent. The figures for the gas producer and oil engine stations which appear in the 1922 return are of considerable interest. The average consumption per unit generated in the case of the former was 2.64, and the best was 1.39, or 1.97 and 1.038 per brake horse-power. The highest thermal efficiency was 15.6, but the average of the four best was only 13.8. Of the fifty-two oil engine stations, which produced but 31.55 million units, against the 4732 million units generated by steam, the lowest consumption per unit was 0.65, with a thermal efficiency of 29.15 per cent. The average of the four best was 0.68, with 28.25 per cent. efficiency. Per brake horse-power, the consumption was 0.485 and 0.507 respectively.

Compared with the internal combustion piston engine, however, the gas turbine can never enjoy the vast advantages over the reciprocating type of mechanism which the steam turbine possesses. It was shown above that the same brake thermal efficiency may be obtained by working comparatively inefficiently on a cycle of high absolute efficiency just as well as by working more efficiently on a cycle of lower absolute efficiency. This is precisely what occurs in the case of the steam turbine and the piston engine. With steam, however, enormous expansion ratios are readily obtainable, in fact, a volumetric expansion of 750 to 1 is not out of the question, and the turbine mechanism lends itself very readily indeed to the utilisation of small pressure differences and the "toe" of the P.V. diagram. It can also utilise much higher superheat than can the engine, for there are no surfaces in contact, as well as vacua which are entirely beyond the range of constructional possibilities where piston and valve mechanism are involved. Increased thermal and mechanical losses with reciprocating mechanism follow any attempt to go far in the direction of utilising the energy of expansion at pressures below about 2 lb. absolute, though there is still useful energy remaining in the steam. The result is that this engine is restricted to a cycle of much lower efficiency. In the internal combustion piston engine, as was shown in Fig. 2 and Table VII.—*ante*—the "toe" of the diagram with atmospheric exhaust only forms a small proportion of the available work, this fraction becoming smaller as the initial pressure increases. But with the products of internal combustion, *which are non-condensible gases*, the advantages of the turbine over the piston engine, in that it can utilise the "toe" of the diagram, very largely vanish, because the expansion ratio is greatly curtailed by the fact that the gas does not change state, and though use can be made of sub-atmospheric working, the limits of the internal combustion P.V. diagram cannot be extended in the same manner as they are with steam owing to the condensation which the latter undergoes. We are, in the internal combustion turbine, as with steam, employing a mechanism of lower intrinsic efficiency with which to extract the available kinetic energy, but whereas, in the latter the limits between which we can readily work are so much greater, and, consequently, so much more energy per pound of working fluid is available, in the former the range of expansion available hardly differs at all in the two cases, and pressure compression ratios in both exceeding 15 offer hardly any advantages with the materials at present at our disposal, as higher compressions involve initial temperatures which become increasingly difficult to handle. The efficiency of a non-condensing steam turbine is notoriously low, and between initial and atmospheric exhaust pressures the piston engine is much superior—is even superior down to, perhaps, 26in. vacuum. The same applies with internal combustion gases, and no little misapprehension has often been caused by lack of appreciation of the fact that the turbine *per se* is inherently less efficient than the reciprocating engine except in the utilisation of the sub-atmospheric range, but that it derives its vastly superior brake thermal efficiency from the fact that it can operate on a cycle of far higher absolute thermal efficiency, and *not* from the fact that its mechanical efficiency or efficiency of energy conversion is better, because it is not so except at very low pressures. When, as the tables show, the absolute thermal efficiency of the internal combustion cycles on which piston engine and turbine work approach one another so closely—although the pressure limits may differ considerably—then the superior efficiency of expansion and of compression in the piston type—an efficiency which may attain 95 per cent. in each case compared with about 70 per cent. in the turbine—causes the internal combustion turbine, considered merely as an economical unit, to lose ground rapidly, although, as Tables VIII. and XI. indicate, its brake thermal efficiency compared with steam may be high. In the case of steam there is no compression, broadly speaking—it is an external heat supply—and the only negative work in the cycle lies in the operation of the necessary auxiliaries, such as air, feed, and circulating pumps. In the case of the heavy oil engine high absolute thermal efficiencies are only obtained at the cost of high compression pressures, which involve a very heavy engine, and, compared with the simplicity of the turbine, a very elaborate and complicated mechanism.

With the limit of velocity compounded turbine efficiency on the low side of 70 per cent. there are two directions in which improvement in the efficiency in internal combustion turbine installations can be made, viz.:—

(1) By increasing the air compressor efficiency, and

(2) By an increase in the ratio of positive to negative work in the cycle.

The former improves the thermodynamic efficiency of the combination, and therefore the brake thermal efficiency for a given cycle. The latter is, perhaps, less a matter of mechanical design, though this effects the same result in a different manner, so much as a question of the selection of cycle limits. What these are can either be shown in tabular form or by means of formulæ, which, however, convey at first sight comparatively little to those who have not studiously investigated the subject. Lines 15, 16, 17, 18 of Table III. indicated what can be done with the C.P. super-atmospheric cycle. Table VII. showed the influence of cutting off the toe of the diagram as is done in Diesel practice. Tables IX. and X. are now

TABLE VIII.—*The Brake Thermal Efficiency of Various Types of Installation.*

Installation.	Lb. of fuel per S.H.P. per hour.	B.Th.U. per lb. of fuel.	B.Th.U. per S.H.P. per hour.	Brake thermal efficiency of engine.	Efficiency ratio.	Boiler efficiency.	Thermal efficiency of engine and boiler.
Heavy Oil Engines.							
Scott-Still experimental engine[1]	0.387	18,053	6,986	36.4	69.7	—	—
Average large marine oil engine[2]	0.41	18,000	7,380	34.5	—	—	—
Camellaird-Fullagar (opposed piston)[3]	0.425	18,260	7,760	32.7	—	—	—
Marine Steam Machinery.							
Geared turbine (oil fuel)[4]	0.75	18,000	13,500	22.6	77.0	83.3	18.85
Geared turbine (oil fuel)[5]	0.85	18,000	15,300	20.5	68.7	81.3	16.63
Geared turbine (coal)	1.16	13,800	16,000	19.5	69.0	81.5	15.9
R.M.S. Saxonia[6]	1.29 (I.H.P.) / 1.52 (S.H.P.)	—	17,800	17.2	62.8	—	14.24
Average quadruple-expansion[7]	1.57	13,800	21,650	14.5	52.0	81.0	11.75
Average triple-expansion[8]	1.77	13,800	24,450	13.5	47.0	77.0	10.4
Electric Generating Stations.							(Approx.)
Average of 463 stations (1920–21)[9]	2.48 (= 3.32 per K.W.)	(8,700)[15]	(21,550)[15]	(16.9)	—	(70.0)	11.8
Best of 463 stations (1920–21)[10]	1.33 (= 1.78 per K.W.)	(10,750)	(14,330)	—	—	—	17.75
Carville, average of tests of five 10,000 K.W. turbo-alternators[11]	—	—	(12,720)	24.9	73.1	Assumed 80.4	20.0
Best station in London district[12]	2.5 (= 3.36 per K.W.)	(7,140)	(17,820)	?(23.3)[16]	(71.8)[16]	—	14.28
Best station in Durham district[13]	2.03 (= 2.72 per K.W.)	(8,810)	(17,880)	?(24.67)[17]	(75.2)[17]	—	14.25
Best station in Lancashire district[14]	2.4 (= 3.22 per K.W.)	(7,610)	(18,250)	—	—	—	13.94
Best station in Yorkshire district[15]	2.45 (= 3.28 per K.W.)	(7,655)	(18,750)	—	—	—	13.58
Best station in Glasgow district[16]	2.22 (= 2.98 per K.W.)	(8,640)	(19,140)	—	—	—	13.3

[1] See Mr. Rennie's paper, I.E. and S., 1922.
[2] N.E.C. marine Diesel papers, January, 1923.
[3] Professor Watkinson's report. See THE ENGINEER, August 11th, 1922.
[4] Guarantee for best performance very large installation, main engines only.
[5] Reported service result.
[6] [7] [8] Ratio $\frac{\text{B.H.P.}}{\text{I.H.P.}}$ taken as 0.85.
[6] Boiler Committee trials.
[9–16] See Electricity Commissioners' Report (1920–21).
[10–11] Carville. See Baumann, I.E.E., 1921.
[12] [13] [14] [15] Presumably Chelsea, Dunston, Manchester and Sheffield, but not so stated.
[16] [17] See efficiency for Parsons two-cylinder machines.
[18] [19] These figures were not given in the Electricity Commissioners' report, but they correspond to the efficiencies and the consumptions per kilowatt, which were given. They are necessarily only approximate.

* No. III. appeared May 18th.

given in order to demonstrate the effect of various modifications of the internal combustion cycle limits in regard to the ratio of $\frac{\text{positive}}{\text{negative}}$ work and absolute thermal efficiency; Table XI. allows a direct comparison of the brake thermal efficiencies on the super-atmospheric and other cycles to be made with the data given in Table IV. (*ante*); and Table XII. shows three chance examples of the variation of brake thermal efficiency with local changes of turbine and compressor efficiency for constant values of K and absolute thermal efficiency. These tables are quoted in order to show the general method of tackling the problem, and as far as the C.P. single-fluid internal combustion turbines are concerned, cover the ground very thoroughly. Where sub-atmospheric figures are given, in order to close the cycle, isothermal exhaustion has been assumed. The resulting efficiencies are therefore distinctly optimistic and are given in order to

This also equals

$$\frac{C\,p\,(T_3 - T_1) - C\,p\,(T_4 - T_1) - R\,T_4 \log_e r}{C\,p\,(T_3 - T_2)} = \frac{(T_3 - T_4 - T_4 \log \frac{T_3}{T_4}}{T_3 - T_2}$$

where R is the constant for the gas equation. In the latter expression the value of $C\,p\left(1 - \frac{1}{\gamma}\right)$ is substituted for R. In the case of the Diesel engine, where the toe of the diagram is cut off as at T_3, the heat is rejected at constant volume instead of at constant pressure. The efficiency is then equal to $1 - \frac{(T_5 - T_1)}{\gamma(T_3 - T_2)}$, where γ is the index of the polytrope.

The least possible amount of negative work is

largest turbo-compressor hitherto built in Great Britain was supplied by Messrs. Frasers and Chalmers for a South African mine. It has normally a capacity of 30,000 cubic feet of free air per minute, and of 36,000 cubic feet overload, when working from a barometric pressure of 24in. against 95 lb. per square inch pressure. The same pressure ratio from a 30in. barometer would mean a discharge pressure of 120 lb. Very great improvements have been made in recent years in the direction of cutting down the number of stages required to produce a given compression ratio, though this has been largely obtained by increasing the peripheral speed of the fans. The two-cylinder compressor referred to has eight fans in series in each cylinder, both of which are completely water cooled, and which are also supplied with a large intercooler. Turbo-blowers for capacities up to 40,000 cubic feet and pressures up to 30 lb. per square inch have also been made, and there seems

TABLE IX.—*The Influence on Thermal Efficiency of Super-atmospheric Cycle as shown in Table* III. *of Variations of* (1) *Exhaust Temperature,* (2) *with Reduced Work of Compression.*

			Furnace temperature varying with exhaust temperature.			Effect of reduced work of compression compared with adiabatic due to stage compression and cooling.					Effect if temperature of compression could be reduced as shown.	
1	Initial pressure, lb. abs.	P_0	←			———	14.7	———				→
2	Initial temperature, deg. Fah.	T_1	←			———	60.0	———				→
3	Final pressure: Compression ratio	P_1	←	34.0	→	6.8	10.0	15.0	34.0	34.0	34.0	34.0
	Lb. abs.		←	500	→	100	147	220	500	500	500	500
4	Work in isothermal compression, B.Th.U.		←	125.5	→	68.5	81.7	96	125.5	125.5	125.5	125.5
5	Temperature after isothermal compression, deg. Fah.	T_1	←				60.0					→
						←	2-stage	→		3-stage	10% T_2	25% T_2
6	Work in adiabatic compression, B.Th.U.	$C\,p$ (7-2)	←	224	→	79	97.5	118	164.5	149.5	202	177.5
7	Temperature after adiabatic compression, deg. Fah.	T_2	←	994	→	230	266	311	465	400	990	800
8	Temperature after adiabatic expansion, deg. Fah.	T_4	945	555	360	←		750		→	750	750
9	Temperature leaving furnace, deg. Fah.	T_3	3460	2375	1830	1660	1906	2201	2921	2921	2921	2921
10	Work in adiabatic expansion, B.Th.U.	$C\,p$ (9-8)	603	436	353	218.5	277	348	522	522	522	522
11	Heat added in furnace (isothermal compression), B.Th.U.	$C\,p$ (9-5)	815	555	425	—	—	—	—	—	—	—
12	Heat added in furnace (adiabatic compression), B.Th.U.	$C\,p$ (9-7)	592	332	201	343	393	454	590	606	486	510
13	Net work done (isothermal compression), B.Th.U.	10-4	477.5	310.5	227.5	—	—	—	—	—	—	—
14	Net work done (adiabatic compression), B.Th.U.	10-6	379	212	129	139.5	179.5	230	357.5	372.5	320	345.5
15	Ratio $\frac{\text{positive}}{\text{negative}}$ work (isothermal compression)	$\frac{10}{4}$	4.8	3.47	2.81	—	—	—	—	—	—	—
16	Ratio $\frac{\text{positive}}{\text{negative}}$ work (adiabatic compression)	$\frac{10}{6}$	2.69	1.945	1.575	2.77	2.84	2.95	3.175	3.49	2.58	2.94
17	Absolute thermal efficiency (isothermal compression)	$\frac{13}{11}$	58.5	56.0	53.6	—	—	—	—	—	—	—
18	Absolute thermal efficiency (adiabatic compression)	$\frac{14}{12}$	64.5	64.5	64.5	40.7	45.8	50.7	60.6	61.5	65.9	68.1

TABLE X.—*The Influence on Absolute Thermal Efficiency of Varying Cycle Limits when Working on Sub-atmospheric Cycle.*

										Combined super and sub-atmospheric cycle, isothermal exhaustion.		
1	Initial pressure, lb. abs.	P_0	←				14.7					→
2	Initial temperature, deg. Fah.	T_1	←				60.0					→
3	Final pressure: Compression ratio	P_1	7.57				6.66	10	15	11.35	15.0	21.3
	Lb. abs.		1.945	←		→	20-3	30-3	45-3	22.0-1.945	29.4-1.945	41.5-1.945
4	Work in isothermal compression, B.Th.U.		72	←		→	10.8 } 67.3 56.5 }	25.3 } 81.8 56.5 }	40.0 } 96.5 56.5 }	14.4 } 86.4 72.0 }	24.6 } 96.6 72.0 }	37 } 109 72 }
5	Temperature after isothermal compression, deg. Fah.	T_1	←				60.0					→
6	Work in adiabatic compression, B.Th.U.	$C\,p$ (7-2)	—	—	—	—	—	—	—	15.7 } 87.7 72.0 }	27.8 } 99.8 72.0 }	43.2 } 115.2 72.0 }
7	Temperature after adiabatic compression, deg. Fah.	T_2	—	—	—	—	—	—	—	125	176	245
8	Temperature after adiabatic expansion, deg. Fah.	T_4	750	855	1154	1419	945	945	945	855	855	855
9	Temperature leaving furnace, deg. Fah.	T_3	1721	1906	2445	2921	1981	2282	2658	2201	2445	3205
10	Work in adiabatic expansion, B.Th.U.	$C\,p$ (9-8)	233	252.5	310	360	249	323	412	323	382	565
11	Heat added in furnace (isothermal compression), B.Th.U.	$C\,p$ (9-5)	399	443	573	687	461	535	624	515	573	755
12	Heat added in furnace (adiabatic compression), B.Th.U.	$C\,p$ (9-7)	—	—	—	—	—	—	—	497	545	710
13	Net work done (isothermal compression), B.Th.U.	10-4	161	180.5	238	288	181.7	241.2	315.4	236.6	285	456
14	Net work done (adiabatic compression), B.Th.U.	10-6	—	—	—	—	—	—	—	235.3	282	450
15	Ratio $\frac{\text{positive}}{\text{negative}}$ work (isothermal compression)	$\frac{10}{4}$	3.24	3.51	4.31	5.0	3.7	3.94	4.28	3.74	3.94	5.18
16	Ratio $\frac{\text{positive}}{\text{negative}}$ work (adiabatic compression)	$\frac{10}{6}$	—	—	—	—	—	—	—	3.68	3.82	4.91
17	Absolute thermal efficiency (isothermal compression)	$\frac{13}{11}$	40.4	40.8	41.5	42.0	39.4	45.0	50.7	46.0	49.8	60.5
18	Absolute thermal efficiency (adiabatic compression)	$\frac{14}{12}$	—	—	—	—	—	—	—	47.4	51.7	63.5

TABLE XI.—*The Influence of Assumed Maximum Practicable Efficiencies of Turbine and of Compressor on the Possible Thermal Efficiency of the Internal Combustion Turbine when Working Under Conditions Modified from those in Table III.* (*See also Fig.* 4 *ante.*)

For Table IX. (super atmospheric) Turbine efficiency = 65%	Isothermal compression, η = 70%	Overall η	44.5	33.4	21.9	—	—	—	—	—	—	—	—
		Brake thermal η	26.0	18.7	11.7	—	—	—	—	—	—	—	—
	Adiabatic compression, η = 90%	Overall η	37.4	16.0	−15.4	38.8	39.7	41.3	43.9	46.4	35.5	41.2	
		Brake thermal η	24.1	10.3	Neg'tive	15.8	18.15	21.0	26.6	28.5	23.4	28.0	
For Table X. (sub-atmospheric) Turbine efficiency = 65%	Isothermal compression and exhaustion, η = 70%	Overall η	30.3	34.0	41.5	45.5	36.2	38.5	41.3	36.6	38.4	46.3*	33.9*
		Brake thermal η	12.2	13.9	17.2	19.1	14.25	17.33	20.93	16.83	19.12	28.0	20.5

indicate tendencies. The efficiency of any cycle, of course, is equal to $\frac{H - h}{H}$, where H is the total heat put in and h the heat rejected, and for the C.P. cycle the efficiencies can be written as follows, using the notation in Fig. 5.

With *adiabatic* compression,

$$\eta = \frac{H - h}{H} = \frac{C\,p\,(T_3 - T_2) - C\,p\,(T_4 - T_1)}{C\,p\,(T_3 - T_2)} = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \left(\frac{1}{r}\right)^{\gamma - 1}$$

where r is the ratio of initial to final pressure.

With *isothermal* compression,

$$\eta = \frac{H - h - h_1}{H}$$

where h_1 is heat unit value of the work done on the compressor (or exhauster).

involved by operating—if one only could—on the isothermal line. By means of cooling, whether stage by stage or by some form of jacketing or of intercooling, it is possible to modify the work of compression considerably. To what extent this can be done is very largely a question for experts on air compressing problems. The tables show ideal performances with air as the working substance; comparisons between them show how the K values and those of Abs. $\theta\,\eta$ fluctuate. It is hardly logical to use a reciprocating compressor for a rotary prime mover, and for large volumes impossible to do so, and, consequently, the effect of two and three-stage working can only be considered as a potential performance, although some of the highest efficiencies are obtainable in this manner, though only at the cost of complication. Then, again, it is important to remember that the present limit reached with rotary compressors is in the region of 120 lb. gauge pressure, though a compression ratio of 10 is probably possible. The

to be no reason why much larger volumes should not be handled. Reduction in size and increase in efficiency, however, are needed, for the relatively low compressor efficiency will always remain a serious handicap on the gas turbine. It must never be overlooked that if L is the effective work produced by the turbine for external use, L_1 the work done by the turbine at an efficiency η_1 and L_2 the work required to be done on the compressor, or exhauster, at an efficiency η_2, then

$$L = \eta_1\,L_1 - \frac{L_2}{\eta_2}.$$

Obviously, L becomes zero when the negative work $L_2 = \eta_1 \times \eta_2 \times L_1$. In other words, if the efficiencies of the turbine and the compressor are both $\frac{2}{3}$, then the ratio of $\frac{\text{negative}}{\text{positive}}$ work must not exceed $\frac{4}{9}$, and

the closer that it approaches this figure, the nearer to vanishing point does the output trend. In the constant-volume turbine, we have not got this compressor loss to contend with, but the mechanical complication is very considerable, and as far as can be seen this cycle will not admit of efficiency equal to that of the constant pressure cycle. In the assumed

TABLE XII.—*The Influence on Brake Thermal Efficiency of Changes in Turbine η with Constant Compressor η, and of Changes in Compressor η with Constant Turbine η.*

Super-atmospheric. With K = 4.16 and Abs. $\theta\eta$ = 57.6 per cent.

Compressor η = 70	Turbine efficiency	63	64	65	66	67	68
	Overall efficiency	37.7	39	40.3	41.7	43	44.3
	Brake efficiency	21.7	21.45	23.2	24.0	24.75	25.5
Turbine η = 65	Compressor efficiency	68	69	70	71	72	73
	Overall efficiency	39	39.7	40.3	41	41.6	42.2
	Brake efficiency	22.45	22.83	23.2	23.6	23.95	24.3

Super and sub-atmospheric. With K = 3.94 and Abs. $\theta\eta$ = 49.8 per cent.

Compressor η = 70	Turbine efficiency	63	64	65	66	67	68
	Overall efficiency	35.8	37.1	38.4	39.8	41.2	42.5
	Brake efficiency	17.82	18.5	19.12	19.82	20.5	21.15
Turbine η = 65	Compressor efficiency	68	69	70	71	72	73
	Overall efficiency	37	37.8	38.4	39.1	39.8	40.4
	Brake efficiency	18.42	18.8	19.12	19.48	19.82	20.1

Super and sub-atmospheric. With K = 5.18 and Abs. $\theta\eta$ = 60.5 per cent.

Compressor η = 70	Turbine efficiency	63	64	65	66	67	68
	Overall efficiency	43.8	45.1	46.3	47.5	48.8	50.0
	Brake efficiency	26.5	27.25	28.0	28.7	29.5	30.25
Turbine η = 65	Compressor efficiency	68	69	70	71	72	73
	Overall efficiency	45.4	45.9	46.3	46.8	47.25	47.7
	Brake efficiency	27.45	27.8	28.0	28.27	28.55	28.8
Turbine η = 55*	Overall efficiency	33.1	33.6	34.0	34.5	35	35.5
	Brake efficiency	20.0	20.33	20.55	20.9	21.2	21.5

* The heat drop here (see last column, Table X.) is, of course, too great for a two-row wheel unless the blade speed be about 1170ft. per second. This line then shows what might be accomplished instead with a three-row wheel at 800ft. per second, provided always that the nozzle will stand the temperature leaving the furnace.

efficiencies of compression in the tables, no distinction has been made between super- and sub-atmospheric working, though it would seem that the reduction in friction should be greatly to the advantage of the former. On the other hand, the rarification of the air may tend to cause the particles of air to be less respondent to the action of the fan than they are in the case of compression. The efficiencies of the compressor which have been used for the purpose of estimating possible brake thermal efficiencies are on the high side, but, *granted suitable conditions*, 70 per cent. is a figure which has actually but very rarely been obtained.

The tables show clearly the necessity of reducing the value of the temperature after compression—line 7. The temperature after expansion is an arbitrary figure, but it is the most important factor in internal combustion turbine design, being, in fact, the cardinal point upon which the whole design hinges. The temperature leaving the furnace is calculated from the formula

$$\log T_2 = \log T_4 \left(\frac{P_1}{P_2} \right)^{\frac{\gamma - 1}{\gamma}}$$

where T_2 and T_4 are the absolute temperatures at the points given in Fig. 5, and P_1 and P_2 the initial

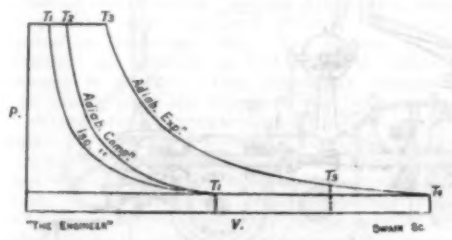


FIG. 5

and final pressures absolute. γ has been taken = 1.41 for both compression and expansion. As shown in Table IX., reducing the final temperature, while lowering the furnace temperature, involves a loss of $\frac{\text{positive}}{\text{negative}}$ work ratio, and *vice versâ*. The question of the utilisation of the gases after expansion intrudes itself here; if the heat is rejected, discrimination needs to be used in the selection of the exhaust T; if it is used for regeneration, as in the Holzwarth turbine or the Still engine, little can be done with it, unless the T is high. Besides this point it is necessary to consider

(*a*) the maximum permissible furnace temperature as regards what the furnace lining and the nozzles will withstand, with or without cooling;

(*b*) the maximum permissible temperature which may impinge on the blades, and

(*c*) the B.Th.U. drop between (1) and (2).

Of these (*b*) is by far the most important; the higher it is, the greater the thermal efficiency of the cycle and the more use it is for regeneration. Below about 750 deg. Fah. it is very little use in the turbine; above 900 deg. Fah. there are two questions to be taken into account, viz.:—

(*a*) the temperature which the blades—*i.e.*, the blade edges, really—will stand, and

(*b*) the influence of the temperature of the medium surrounding the wheel on the strength of the rotor material.

These two temperatures may not be identical; that is, the diminution in strength may restrict the temperature to something below a safe figure for the blades, or *vice versâ*. Holzwarth has exceeded 950 deg. Fah., though he suggests that this is about a safe maximum. Rateau has gone to a much higher figure. The permissible B.Th.U. drop is governed by the necessity of working at very nearly the most efficient ratio of blade speed to gas speed—about 0.22 from Fig. 3 (*ante*)—with a two-row wheel. What, then, is the maximum blade speed which we dare employ? The standard Laval speeds are satisfactory in practice, but the highest speeds are too great when the wheel is running in 900 deg. Fah.

Revs. per minute	20,000	16,000	13,000	10,600
Mean diameter, inches	8¼	11¼	19¼	30
Blade speed	775	784	1122	1390

In large impulse steam practice, with low-pressure wheels exceeding even 10ft. in diameter, 800ft. per second has been exceeded, but it is very high for a large forging. With gearing and small forgings it is not excessive when using the temperatures met with in steam practice. With the reduction in strength of material due to heat, the future vane speeds lie almost entirely in the hands of the metallurgist. Meanwhile, for ratios of $\frac{\text{blade speed}}{\text{gas speed}}$ of 0.2 to 0.22, the heat drop permissible is restricted as follows:—

Blade speed, feet per sec.	700	750	800	850	900
B.Th.U. drop for 0.22	202	232	265	298	335
B.Th.U. drop for 0.20	222	255	292	328	368

These drops are increased by the inefficiency of the nozzle, which may be as much as 0.90. These blade speeds are only obtainable with special designs of discs, the shape being a concavo-convex form chosen so that the disc is of constant strength throughout. Very high rim speeds can be obtained depending on the ratio of the thickness of the disc at the centre to that at the edge. For a ratio of 10, Fig. 6 shows the tensile stresses involved. The problem for the metallurgist is to produce a material which will retain at temperatures exceeding 900 deg. Fah., or so, which is about the present limit to which we dare go, a strength sufficient to admit of a reasonable factor of safety. There are obvious latitudes in which to work by reducing the ratio of blade speed, $\frac{\text{blade speed}}{\text{gas speed}}$ and hence the thermo-dynamic efficiency of the turbine—as shown in the curves in Fig. 4—and yet without sacrifice of the brake efficiency owing to the possible increase in absolute thermal efficiency, or for the same cycle limits the vane speed can be dropped slightly in order to afford a greater factor of safety.

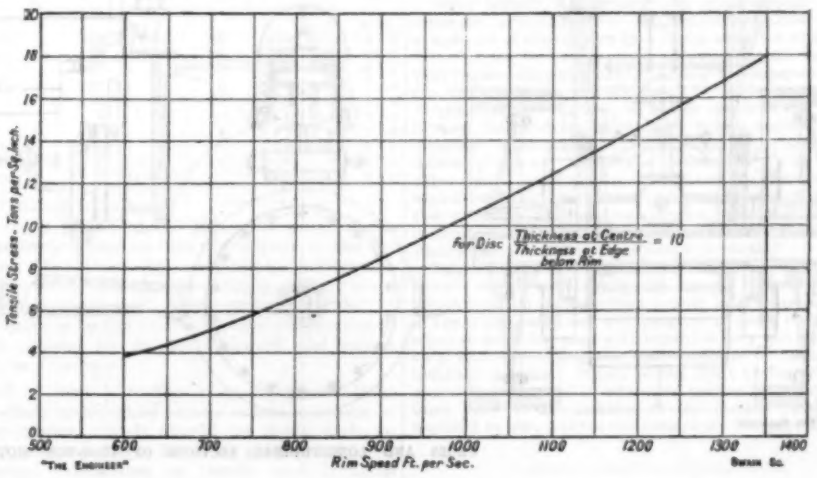


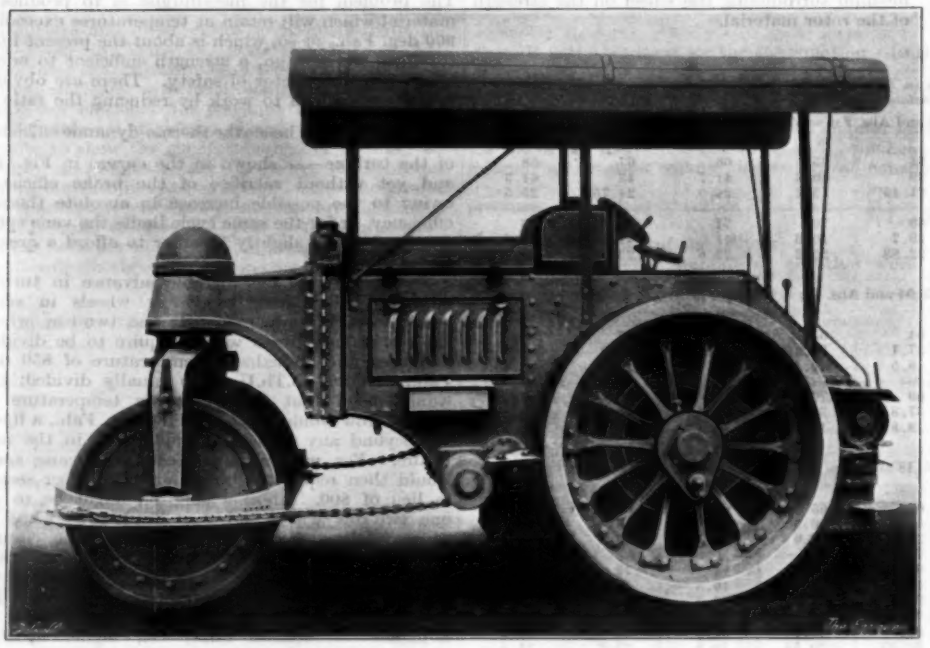
FIG. 6

To obtain the considerable advance in turbine efficiency which two single-row wheels in series would permit compared with one two-row wheel, the above heat drops would require to be divided, and assuming an exhaust temperature of 850 deg. Fah., and 292 B.Th.U. drop equally divided, this would mean that the impinging temperature on the first row would be about 1460 deg. Fah., a figure far beyond any chance of application in the near future. For maximum efficiency the vane speed would then require to be about 1200ft. per second in lieu of 800. Another solution might be to use one two-row wheel and one single-row wheel in series, with 800ft. per second; under the circumstances, the second wheel would only absorb about 64 B.Th.U. in lieu of 146, and the temperature striking the first wheel would be about 1120. The total B.Th.U. drop would then be 356, allowing for a higher compression ratio, *i.e.*, higher absolute thermal efficiency with a brake efficiency intermediate between the two other conditions. This brief calculation shows the impossibility, at present, of using the more efficient turbine unless the total heat drop is very small, too small—in fact, to allow of adequate output from the machine, a factor which always requires consideration. Restricted, then, to the one two-row velocity compounded wheel, it must be remembered that while no increase in turbine efficiency above the limits shown in Fig. 4 is possible even with increase of wheel speed, yet small increases here and in the impinging temperature, which will result from increased experience and from application to the problem, will enable gradual improvements to be made in the brake efficiency by extending the cycle limits. The B.Th.U. drops suggested above are shown on reference to the tables to restrict working to a compression ratio between about 7 and 15 $\frac{P_1}{P_2}$. With 850 deg. Fah. exhaust T, the maximum furnace temperature will not exceed about 2450 deg. Fah., and the ratios of positive to negative work—K values—depend on the cycle chosen and of which the tables indicate the tendency. Here we must leave the theory and revert to the practical considerations, which limit the efficiency to a figure below those obtainable on the air-cycle owing to the nature of the practical working fluids which can be used. Other factors, on the other hand, more than restore this balance, so that the net efficiency, taking into account the value of the heat in the exhaust gases, is actually distinctly above the brake thermal efficiencies given in the tables.

THE Otago (N.Z.) Provisional Electrification Committee, Dunedin, has adopted a report presented by its engineer, Mr. A. P. Aldridge, for a district power scheme. Power will be supplied from Port Chalmers to Palmerston, and the whole scheme is estimated to cost £150,000.

12-14-TON MOTOR ROAD ROLLER

JOHN FOWLER AND CO. (LEEDS), LIMITED, ENGINEERS



Motor Road Rollers.

A NEW type of motor road roller has just been introduced by John Fowler and Co. (Leeds), Limited. It is made in three sizes, the weights in working order of which are (*a*) 4 or 6 tons, (*b*) 8 or 10 tons, and (*c*) 12 or 14 tons. The accompanying engravings illustrate the largest of the three sizes. The roller, which, as will be gathered from the half-tone view of it, is a particularly business-like-looking machine, is built to a certain extent on the lines of the ordinary steam roller. The front rollers—there are two of them, arranged side by side—revolve in a fork, and can adjust themselves to irregularities of the road surface by means of a universal joint. The forecarriage head, which is of a specially patented design, is furnished with a coiled spring, as will be seen in the drawing. Steering is effected by chains to the fork in the usual way, the motion of the steering wheel being transmitted by worm and worm wheel, the fork being furnished with ball bearings to facilitate the operation. The forecarriage head bracket is bolted to channel steel side frames, which are reinforced by steel side plates, which, in their turn, are carried backwards to receive the hind axle and draw-bar. The front rollers, which are, together, 4ft. 1in. in width, overlap the paths of the rear wheels to a considerable extent, so that, even when turning corners, there is no part of the road surface which is unrolled. The weight of the roller is evenly divided between front and rear axles, so that uniform work is possible. The hind rollers or driving wheels are, in the 12–14-ton machine, 5ft. 6in. in diameter and 1ft. 6in. wide, and the hind axle is fitted with side springs fitted in the axle-boxes.

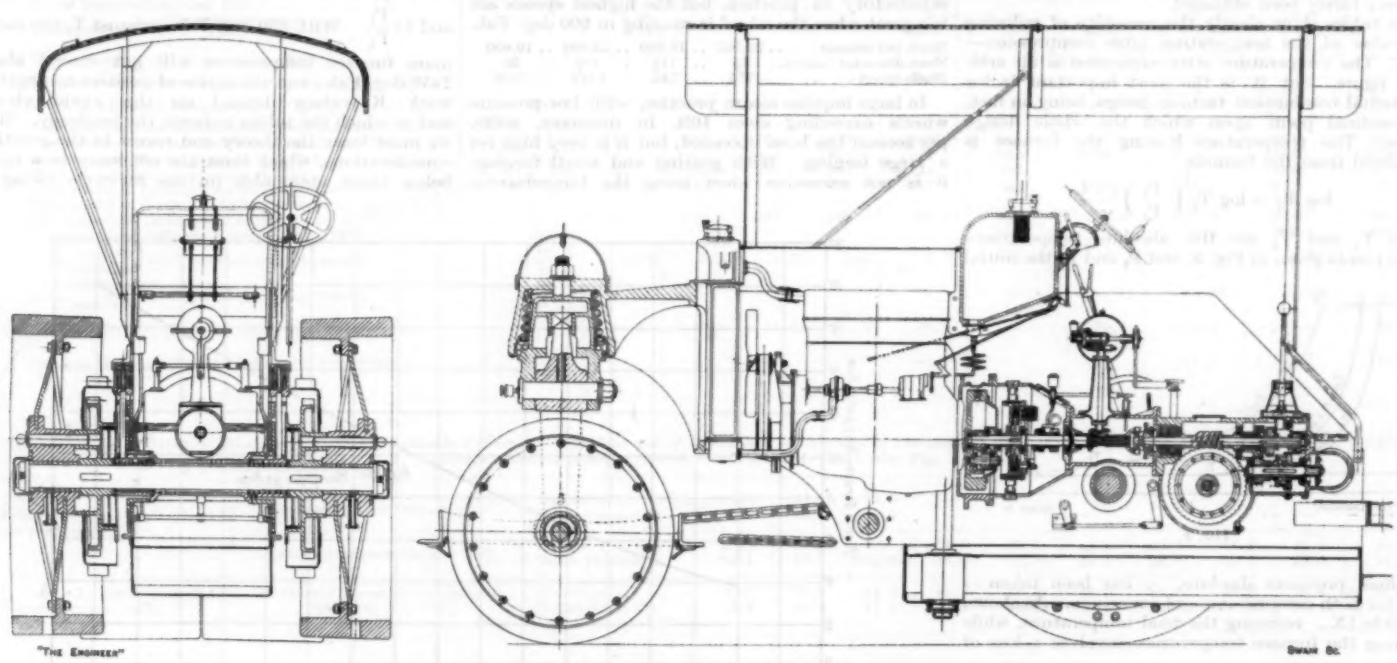
The engine, which has four cylinders and is of the vertical type, is designed to develop 40 brake horse-power at a speed of 1000 revolutions per minute. It is fitted with overhead valves, and has a detachable cylinder head which is fastened by through bolts to the crank case. The breathing of the engine is accomplished by means of tubes, which enclose the valve push rods, so as to ensure that the mechanism may work in a continual oil mist. The lubrication of the main and big end bearings is of the forced feed type, the pressure varying automatically with the load on the engine, and the oil being drawn from a sump in the crank case. The cam shaft bearings, on the other hand, are lubricated from the splash of the crank case. A Zenith carburetter is fitted. It is suitable for either petrol or benzol, and is controlled, alternatively, by hand or by the governor. A special vaporiser for use with paraffin can, however, be fitted. Ignition is by high-tension magneto, the machine being in a water-proof case. There are the usual radiator and fan, and the water circulation is effected by a rotary pump. The radiator is fitted behind the front rollers, and in much the same position as is the smoke-box tube plate in a steam roller. The top of it and its filling cup can be seen in the half-tone engraving. In this position, it is claimed, it is well protected from any risk of damage, and does not carry any of the twisting stresses caused by inequalities of the road.

The clutch is composed of flat plates lined with Ferodo. The gear wheel shafts are mounted on roller bearings, and all the gear mechanism is totally enclosed so that it can run completely immersed in oil. The final drive is by means of a large diameter spur wheel, which is keyed to the axle. A Ferodo-lined brake, which is very powerful and can be operated by hand wheel from the driver's seat, is provided on the final drive. There are three road speeds varying from 1½ to 3½ miles per hour, the gears being operated by gate type change levers and spring forks. Reversing is brought about by means of the firm's special epicyclic gear, which is operated by a lever in very much the same way as is a steam reversing gear. The alteration in the direction of movement at all three speeds is brought about immediately without disengaging and re-engaging of gears. The makers point out that as a road roller is going backwards and forwards all day long, there is considerable advantage in having this method of reversing—especially since it can be done safely on a hill without having to block the wheels—and that it makes the engine much easier to drive. The differential gear can be locked from the driver's footplate. The drive to the belt pulley, which is provided so that the engine can be used for driving machinery, is engaged by the road gear lever, so that the pulley, which is on the near side of the cab, cannot be engaged while the roller is in motion. The pulley has a diameter of 12in. and a width of 6in.

Other particulars of the 12–14-ton roller are given as being approximately as follows:—

Height	7ft. 2in.
Height over awning	10ft.
Total width rolled	6ft. 3in.
Overall length	15ft. 9in.
Wheel base	9ft.
Fuel tank capacity	25 galls.

The figures relating to the smaller-powered rollers are in some cases less than the foregoing, but they need not be particularised here. All that need be said is that the 8–10-ton roller has a 35 horse-power engine, and the 4–6-ton machine a 30 horse-power engine. In general design, all three sizes of rollers are very much the same.



CROSS AND LONGITUDINAL SECTIONS OF 12-14-TON MOTOR ROAD ROLLER

INSTITUTE OF TRANSPORT.

THE third Congress of the Institute of Transport will be held at Sheffield on June 14th, 15th and 16th next. The meetings will be held on the mornings of the two first days at the Cutlers Hall, the afternoons of the two days and the morning and afternoon of the Saturday following being devoted to the visits. On Wednesday, June 13th, from 8 to 10.30 p.m., the President will hold a reception at the Grand Hotel; on Thursday, June 14th, from 8 till 11 p.m., the Lord Mayor of Sheffield will entertain the Congress at a conversazione at the Town Hall; and on Friday, June 15th, from 8 till 11 p.m., the Master and Mistress Cutler will entertain the Congress at a conversazione at the Cutlers Hall.

The following papers will be read and discussed:—"A Railway subject," title and author to be announced later; "Air Transport," by Major-General Sir W. Sefton Brancker, K.C.B.; "Modern Trackwork and its Importance," by Sir Robert A. Hadfield, F.R.S.; "Cargo Handling at Ports: British and American Practice Compared," by Dr. Bryssom Cunningham, M. Inst. C.E.; "Some Comparisons of British and American Methods in Road Construction and Maintenance," by Mr. A. Dryland; and "Tramways from a Traffic Point of View under Existing Conditions," by Mr. E. S. Rayner.

The following visits have been arranged:—On Thursday, June 14th, to either of the following: The works of Hadfields, Limited, at Tinsley; the River Don Works of Vickers Limited, and of Metropolitan Vickers, Limited, at Sheffield; the works of Steel, Peach and Tozer, Limited, at Rotherham; the works of the Parkgate Iron and Steel Company, Limited, at Rotherham; the Applied Science Department of the Sheffield University. On Friday, June 15th, to either of the following: The works of Cammell Laird and Co., Limited, at Penistone; the works of the Staveley Coal and Iron Company, at Staveley; the works of John Brown and Co., Limited, and of Thos. Firth and Sons, Limited, at Sheffield; the railway and tramway carriage and wagon works of Craven, Limited, at Darnall; the works of Edgar Allen and Co., Limited, at Sheffield; and the locomotive works of the London and North-Eastern Railway at Doncaster. On Saturday, June 16th, to either of the following: The Sheffield Corporation electric power station, at Neepsend; the docks of the London and North-Eastern Railway at Immingham and Grimsby; and the docks, &c., of the Aire and Calder Navigation at Goole.

ACCORDING to reports from Sydney, it has been stated on good authority that the Federal Government will not dispose of its large dockyard at Cockatoo Island, N.S.W., but that it intends to reorganise it.

Atmospheric Pollution and Fog Prevention.

IN November of last year the London County Council instructed its Public Control Committee "to consider and report how far fog in London is caused by the pollution of the atmosphere due to preventable causes; whether by a larger use of electricity for power and other purposes the atmosphere of London might be improved, and whether, and if so, what further powers are required to deal with the emission of smoke in London." The Committee has just recently presented its report, as was briefly announced in our last week's issue, and in what follows we propose to give a general summary of it.

In a preliminary survey of the problem mention is made of the fact that fog, as distinct from mist, is caused by the pollution of the atmosphere by the emission of smoke—mainly in the consumption of coal—and that "it must not be overlooked that mist, the carrier of fog, cannot be dissipated by human agency." Among the conditions which produce mist are low temperature, a degree of aqueous saturation of the atmosphere, and a stillness of atmosphere without strong movement either horizontally or vertically. Absolute atmospheric stagnation is of rare occurrence in England in winter time. Owing to industrial conditions in the east of London it is probable that the worst of London fogs are coincident with an air drift from the east. "If the smoke conditions of London and of the populous surrounding area were mitigated, there is reason to believe that, on account of the extent of drained area and the artificial warmth of the city, conditions favourable to the formation of fog would not arise so readily in London as in the surrounding areas."

It is then pointed out that gas in common with electricity provides a means whereby power and heat can be obtained without the production of heat, and that both electricity and coal gas can be produced without any serious emission of smoke. "The power-houses of London electricity undertakings give rise to smoke nuisance only when their furnaces are worked negligently or get out of order, or where the boiler power is insufficient. Some smoke is unavoidable in the manufacture of coal gas, as, for instance, when the retorts are opened for re-charging. It should not, however, be a difficult matter—nor, in the working costs of the retort-house, an expensive item—to draw this smoke to a common outlet and there filter it from solid particles." The Committee, after discussing the amounts of coal used in the London gas and electricity works, proceeds as follows:—"Every gas fire, gas cooker, gas engine, and gas-heated appliance and every electric appliance performing any of the same offices represents a substitute for some kind of smoke-producing fire, and the use of these appliances should, in our view, be encouraged."

Fog in London, the report proceeds to point out, is caused by the pollution of the atmosphere arising from:—(*a*) Domestic chimneys; (*b*) industrial operations; (*c*) railway and road locomotives; and (*d*) steam vessels on the river Thames and its subsidiary waters. To a considerable extent this pollution is preventable, but in view of economic and practicable considerations it is not wholly so. Reference is made to the exhaustive investigation of the matter recently carried out by the Departmental Committee on Smoke and Noxious Vapours Abatement, which was presided over by Lord Newton, and which reported in December, 1921. The findings of this Committee are set out in full, and the following comment is made:—"One important conclusion to be drawn from the report of the Departmental Committee, from previous investigations of the subject, and from the Council's experience, is that steam-raising plant, plant for producing large supplies of hot water, or for the heating of large buildings by hot air, steam or hot water, railway locomotives and the boilers of steam vessels, *can* be constructed and worked so as to produce very little visible smoke. When an engineer has regard to the calorific value of the coal supplied, the condition of his furnaces and the methods of his stokers, he not only does not offend in the matter of smoke emission, but he also works his furnace with an economy in coal consumption not otherwise obtainable."

The four main causes of atmospheric pollution referred to above are then dealt with *seriatim*, the data on which the findings are based being afterwards referred to:—

Domestic Chimneys.—The domestic chimney is undoubtedly one of the causes of atmospheric pollution. The practical consideration is whether a remedy can be found under existing conditions. The Committee's view is that there is none beyond inducing house builders to employ types of grates and grate settings that have been found by experience to be effective for warming purposes and largely smokeless when burning bituminous coal, or to which electric appliances, gas stoves or gas cookers can be fitted satisfactorily and with due regard to appearance. It is clearly desirable, therefore, it continues, that all new grates fitted in domestic houses or buildings used for dwelling or office purposes should be of approved types. The Committee further expresses the opinion that the time has arrived when the use of the old-fashioned kitchener might well cease. As compared with modern electric and gas cooking appliances, it is, it remarks, "inefficient and out of date and probably wasteful of fuel. It must be held responsible for a very large proportion of smoke arising from domestic chimneys."

Industrial Operations.—The most notable of large coal consumers are the various electricity generating stations belonging to railway and tramway authorities and to the lighting authorities or companies. With regard to them all the Committee states that they have not, with a few exceptions, seriously offended for a number of years, and the example they have set establishes the truth of the assertion that steam-raising plant can be constructed and worked without causing smoke nuisance.

(*c*) *Railway Locomotives.*—Smoke arises from railway locomotives while they are being fired-up from cold and when running. Under this heading it is remarked that a little observation of railway termini and tracks and engine sheds in the County of London will give some indication of the amount of smoke that is daily discharged from railway locomotives in London. In some parts a condition of localised fog is of frequent occurrence. But, goes on the report, "As a matter of fact, the locomotive can be fired-up and worked without the production of much smoke. A good driver will work his engine at a coal consumption per mile much less than the majority of drivers, and the care which secures this economy in coal consumption incidentally gives a fire which maintains a sufficient head of steam with a minimum of smoke. . . . Some engine sheds are fitted with flues suspended over the track and dropping to a level sufficient to enable the smoke from the engine to be carried away through the flue, the several flues leading by a main flue to a common outlet. . . . If all the railway companies would adopt this practice and, in addition, would filter the smoke at the point of outlet, a considerable reduction of smoke nuisance would result at small cost to the companies."

Steam Vessels.—As concerns steam vessels, the following pronouncement is made:—"Observation of the river Thames and its waterways, either from the bridges or the neighbourhood of the docks, indicates that smoke nuisance thereon arises to a serious extent. Marine boilers do not, however, differ materially from those used in factories and railway locomotives, and with proper attention to stoking and the character of the fuel used, there should be little smoke nuisance."

After referring to the law with regard to smoke consumption, the report goes on to state that, in spite of various deficiencies in the law, to which attention is drawn, smoke conditions over London have—omitting the war period—greatly improved during the last twenty years. In proof of this assertion—so far as locomotives are concerned—the following table, which sets out the action taken by the London County Council in the matter of smoke nuisance from railway locomotives during the three five-yearly periods 1899–1904, 1904–1909, 1909–1914, is given:—

Name of railway company.	5 years, April, 1899, to Mar., 1904.	5 years, April, 1904, to Mar., 1909.	5 years, April, 1909, to Mar., 1914.	Total number of convictions.	Total amount of penalties and costs. £	s.	d.
L.B. and S.C. ..	331	248	40	619	1717	16	6
S.E. and C... ..	178	146	66	390	1099	6	0
G.E.	67	40	16	123	344	16	0
L. and N.W. ..	40	20	9	69	141	7	0
G.N.	8	37	21	66	183	4	6
L.T. and S... ..	7	14	—	21	61	15	0
Midland	2	12	3	17	42	7	0
Metro. District ..	—	2	—	2	4	6	0
North London ..	1	1	14	16	50	6	0
Millwall Dock ..	1	—	—	1	3	3	0

Attention is drawn to the fact that some of the London railway companies do not appear in the list at all, and that there are considerable differences between the worst offenders and the remaining companies, the names of which do appear in the table.

After reference to the powers of local authorities in regard to actions for smoke nuisance, the report concludes as follows:—

"It will be seen from the foregoing observations that the whole question of smoke nuisance is one of great importance, which should be dealt with on broad and comprehensive lines, as proposed by the Departmental Committee on Smoke and Noxious Vapours Abatement. . . . Smoke, especially in association with fog, affects the health and well-being of dwellers in great centres of population, entails needless expense, is destructive in its action and seriously retards traffic. The problem has now become so acute that a well-thought-out and properly co-ordinated solution is long overdue. The existing law on the subject is chaotic and largely ineffective and requires codification; local authorities are ill-equipped with the necessary powers for enforcing compliance with statutes; and there exists at present no encouragement to manufacturers and others to diminish the large volumes of smoke daily poured into the atmosphere. After full consideration, we are strongly of opinion that His Majesty's Government should be urged to introduce, at an early date, legislation on the lines indicated in the report of the Departmental Committee."

Mid-Lancashire Electricity District.

THE Electricity Commissioners have considered the evidence given at the inquiry held at Preston in February last into (*a*) the scheme submitted jointly by the Corporations of Blackburn and Preston providing for the establishment of a Joint Electricity Authority; (*b*) the scheme submitted by the North-East Lancashire Electricity Committee providing for the establishment of an Advisory Board; and (*c*) an agreed amended scheme submitted by both parties during the course of the inquiry, and providing for the establishment of an Advisory Board. The conclusions and decisions of the Commissioners are set out below:—

(1) The area of the district as provisionally determined is confirmed.

(2) Under the agreed technical scheme it is proposed to deal with the district in two portions, the provisions made for development being as follows:—

(*a*) *The Central and Eastern Area.*—The new stations at Blackburn and Preston are to be utilised under the scheme, together with the existing stations at Accrington, Burnley, Colne, Darwen, Nelson and Rawtenstall, which are not to be further extended, except in the case of the stations at Nelson and Rawtenstall, and unless otherwise determined hereafter in the case of the stations at Colne and Darwen. Provision is also made for the shutting down in due course of the two existing stations at Preston and the Jubilee-street station at Blackburn. The scheme further provides for the establishment during the first stage of development of transmission lines between Preston, Blackburn, Accrington, Burnley, Brierfield, and Nelson, to supplement the lines already existing between Blackburn and Darwen, Nelson and Colne, Accrington and Rawtenstall *viâ* Haslingden, and between Rawtenstall and Bacup. As regards subsequent developments, it was agreed that further consideration should be given to the question of establishing a main transmission line connecting Rawtenstall with the main system. A new generating station is also to be erected at Padiham, when required, either by the Corporation of Burnley or by the Lancashire Electric Power Company, both of whom expressed their willingness to construct the station. Provision is made for the submission to the Commissioners of a scheme of control of the interconnected generating stations.

(*b*) *The Western Area.*—The generating stations at Blackpool and Fleetwood are to be extended and utilised under the scheme, together with the station at Lytham-St. Annes, which is not to be further extended unless otherwise determined hereafter. Provision is also made for the giving of supplies from the Blackpool station to Bispham and to Lytham-St. Annes. The Commissioners approve generally the proposals embodied in the amended technical scheme.

(3) The agreed scheme of administration provided for (*a*) the establishment of an Advisory Board; (*b*) the appointment of an Engineering Committee for the whole district; and (*c*) the appointment of three sub-committees for the central, eastern and western areas respectively, to deal with matters affecting solely the interests of the authorities within the said areas.

With regard to the proposed constitution of the Advisory Board, it appears to the Commissioners that in the circumstances of the district, there would be some advantage in making provision (*a*) for the direct representation of local authorities other than authorised undertakers instead of for the County Council as proposed; and (*b*) for the representation, either jointly or otherwise of other authorised undertakers established hereafter in the district.

With regard to the proposed appointment of three separate administrative sub-committees, the Commissioners are of the opinion that this is a matter which should be left open for the present. Having regard to the fact that the co-ordination of engineering development throughout the whole district would fall to be dealt with by one Engineering Committee, it is not clear to the Commissioners that definite advantages would accrue from the proposed subdivision of the administrative duties of the Advisory Board. While the Commissioners do not consider that a case has been made out for the compulsory appointment of sub-committees, they see no objection to the granting of enabling powers, whereby such sub-committees could be appointed in the future if the circumstances were found to justify such a course.

Subject to the foregoing observations, the Commissioners approve generally the agreed proposals for the administration of electricity supply in the district.

The Commissioners will prepare a draft Order giving effect to their decisions with regard to area and administration, and embodying the main outlines of the approved technical scheme. Copies of the draft Order will in due course be forwarded to interested parties for their observations prior to the holding of the further local inquiry required by Sec. 5 (4) of the Electricity (Supply) Act, 1919.

THE French Minister of Public Works—Monsieur le Trocquer—has approved the first section of the programme for the electrification of the Orleans and Midi railway systems. For the Midi Railway, the programme from 1923 to 1927 affects 1576 kiloms., and includes—in addition to the line from Toulouse to Dax, with a branch serving the Pyrenees, where the work of electrification is already well advanced—the line from Bordeaux to Irun and its branch lines to Le Verdon, Arcachon, Biarritz, Puyo, Mauleon, Saint Palais, San Jean Pied de Port and Saint Etienne de Baigorry; the extension of the trans-Pyrenean lines to Pau and Laruns; Portet-Saint Simon and Boussens, and several lines to the north of the Toulouse-Dax line. The first section of the Orleans line to be electrified will be the section from Paris to Brive, with the Bretigny-Dourdan branch line and the lines from Saint Sulpice Laurière to Gannat and Brive to Clermont, making a total distance of 916 kiloms.

TRACK CIRCUITING THE MEUDON TUNNEL

Track Circuiting the Meudon Tunnel.

THE line from Les Invalides to Versailles, *viâ* Issy, was opened by the former Western Railway Company of France in three stages, the last to be completed being the section from Meudon-Val-Fleury to Versailles, which was brought into use on May 31st, 1902. On this section, and situated between Meudon and Chaville-Velizy, is a tunnel, 3362 m. (3677 yards) long, under the Bois de Meudon, through which the line ascends towards Versailles on a gradient of 1 in 80. The terminus at Versailles is 102 m. (334ft. 8in.) higher than Les Invalides, 17.6 kiloms. (10.94 miles) distent. Partly because of the difficulty of satisfactorily ventilating this tunnel, were steam operation adopted, the line has, since its opening, been worked electrically. The current is direct at 600 volts, and is supplied through a third rail, the return taking place through the running rails.

The signals on each side of the tunnel are actuated by the usual mechanical appliances, controlled by track circuit. Because of the forest overhead, the tunnel is a very damp one, with, as a consequence, a very low ballast resistance—as low as 2 ohms per 1000ft. The condition is not unlike that of the salt-impregnated track under the river on the Mersey Railway, where, as described in THE ENGINEER of July 7th last, the insulation resistance of the ballast had been reduced to an almost negligible amount, and on one section of track, 367ft. in length, it was as low as 0.105 ohm. A yet further difficulty was the length of the track circuit sections. On the down line the section extended from the starting signal for Meudon to the home signal for Chaville-Velizy, a distance of 3561 m. (3894 yards). On the up line the section was divided. That portion nearer Versailles was 2575 m. (2761 yards), and that nearer Paris 1153 m. (1261 yards). The 3561 m. circuit controls three signals at Meudon Station, whilst the two circuits in the up line control three signals at Chaville-Velizy.

The two longer track circuits have been made possible by the use of a new form of impedance bond—an impedance bond is provided at the end of track circuits on direct-current electric railways to insulate the alternating current track circuit whilst giving a continuous path to the direct-current propulsion current. The new type in question is the resonated impedance bond which has an impedance of over 2 ohms at 25 cycles and provision is made for 200 ampères unbalanced current between the two rails—this being a very heavy allowance. Each half of the winding has a resistance to direct current of .00018 ohm. For the 1153 m. circuit, the ordinary impedance bond is used. The 3561 m. circuit is, we believe, the longest track circuit working under such conditions in the world, and its successful operation has only been made possible by the resonated impedance bond.

The impedance bonds, impedance coils and track relays were sent from England by the Westinghouse Brake and Saxby Signal Company, 82, York-road, N. 1. The track transformers and other apparatus were supplied by the Cie Générale de Signalisation of Paris.

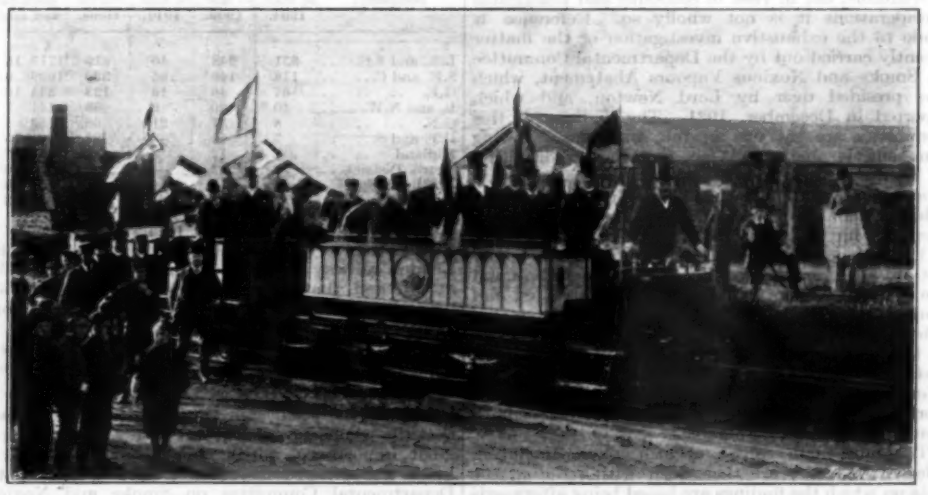
The illustrations above show, on the left, a two-element vane relay and terminals, a case containing the condenser for the impedance bond, and the impedance bond itself in the "four-foot," and, on the right, is seen the resonated iimpedance bond in the down-line at the outgoing end of the tunnel.

The First Electric Tramway.

THE present year marks the fortieth anniversary of the opening of the first hydro-electric tramway of the world. The illustration which we give shows the starting of the first electric car at the opening of the Giant's Causeway electric tramway in 1883 by Earl Spencer—the Red Lord—when Lord Lieutenant of Ireland, along with a distinguished company of scientists. Thus was inaugurated the passing from what might be called the experimental or toy stage of electric-driven cars to the region of the practical demonstration of the utilisation of the dormant water power of our rivers for generating electricity for driving electric tramcars along a tramway at a distance from the source of power.

The experiment was a bold one. Electricity was still in its infancy, and to attempt to introduce a new motive power to be called "electric traction" to supplant horse and steam power upon tramways and light railways was venturesome indeed. The credit for this great step must be given to Mr. William A. Traill, the originator, the engineer and constructor of the Giant's Causeway electric tramway, a line eight miles long with heavy gradients, 1 in 24, for which he had obtained parliamentary powers in 1881. He proposed to utilise a waterfall on the river Bush to generate the electricity for driving the tramcars to Dr. Siemens—later Sir William Siemens—who designed the first electric plant. For twelve months experiments were carried on with failure after failure and constant breakdowns of the cars, but by stubborn perseverance success was ultimately attained and the line was at length opened in 1883 with a public service.

Originally, the current was collected from a side conductor or third rail, which was later replaced by the overhead trolley system. In 1884 Mr. Traill patented the underground or conduit system for electric tramways for towns, and exhibited a model at the Manchester Inventions Exhibition. Some twenty years later he saw the adoption of that plan upon the Metropolitan Electric Tramways system.



OPENING OF THE GIANT'S CAUSEWAY ELECTRIC TRAMWAY, 1883

The Canadian Iron, Steel and Machinery Market.

A GENERAL industrial improvement in Canada is indicated in the output of pig iron for March, which was more than 100 per cent. better than the average monthly production during 1922. The increase in steel billets and castings also indicates that producers of finished steel have fuller orders booked than for the past two years, and that industry in general is increasingly interested in steel. With prices tending upward, this is an encouraging sign of sustained strength in the market, and an evidence that tonnages on order and in shipment are in enhanced volume.

Several of the largest contracts for constructional work and machinery equipment that have been undertaken in Canada for years have recently been awarded. They include the projects for power production on the St. Maurice River in the province of Quebec, in connection with paper mill and general manufacturing enterprises; new storage and grain-handling equipment for the port of Montreal, and the erection of new grain elevators at the head of the Great Lakes. These contracts have, in the main, been awarded to local companies, both for construction and equipment. But the latter is in such exceptional volume as to render imperative large importations of

steel products, notwithstanding the effort of at least two of the principal Canadian steel works to overtake requirements by extensive additions to their plants. The situation in this respect is reflected in the experience of the Canadian agency in Montreal of a Sheffield firm manufacturing a special quality of high-speed steel, which reports that the sale of steel for the past three months has equalled the cumulative sales of the first seven months of 1922. A similar improvement in the demand for steel is reported in other quarters.

Considerable activity in railway construction and equipment is assured by the definite announcement of new undertakings by the Canadian Pacific, Canadian National and Ontario Government Railways. The C.P.R. will spend this season about 8,000,000 dollars on extensions, will purchase equipment to the value of over 12,000,000 dollars, and will construct 97 miles of new line. This will mean larger orders for locomotives and cars, as well as for machinery and rails. The announcement made in Parliament that the Government will proceed with the completion of the Hudson Bay Railway as expeditiously as Federal finances will permit, means a large outlay on the repair and equipment of some 120 miles of the road.

Returning from an inspection of the route of the Ontario Government Railway last week, the general manager gave public assurance of the decision of the Commission to extend the line to its northern terminus, on James Bay, with all possible expedition, an earnest of which undertaking was immediately forthcoming in more vigorous prosecution of construction on the section of the line which is to serve the northern mining districts. The Canadian National Railways have begun work on double tracking 23 miles of line between Port Arthur and Kakabeka Falls.

Permits for the erection of several large buildings in Montreal and Toronto, which were taken out at the end of April, promise further activity in the demand for structural material. Adequate supply of mechanical labour is, however, giving contractors some concern, as is shown by the strenuous effort which the Toronto Builders' Exchange is putting forth to attract mechanics to that city.

The Steel Company of Canada still maintains a base price of 3.10 dollars per 100 lb., but as it is accepting only select orders, the trade regards that quotation as merely nominal, and looks for an upward revision of prices along conservative lines.

In Toronto a range of from 3.75 to 4.00 dollars for bars, with a tendency toward the latter figure, is typical of the present market. An advance in wrought pipe, for which, especially in the larger sizes, there is an active demand, is also looked for. The quotations at the beginning of May were steady around 9.00 dollars, while Montreal reports indicated that mills had advanced their price 30 cents per 100 lb.

Enhanced mining activity in British Columbia and in Northern Ontario should greatly stimulate importation of machinery. Official reports place the production of British Columbia mines for last year for 35 million dollars, an increase of 25 per cent. over the previous year, and the same authority predicts a production of between 40 and 50 million this year. There are in the Northern Ontario goldfields twenty mills at present in operation, and four more projected for the early future, whilst five of the producing mines are planning to increase their output of ore. A total production of 50 million dollars in gold annually is looked for as Ontario's yield by 1924.

THE INSTITUTION OF MINING ENGINEERS.

THE seventy-ninth general meeting of the Institution of Mining Engineers will be held at Glasgow, by invitation of the President and Council of the Mining Institute of Scotland, on Tuesday, Wednesday and Thursday, June 12th, 13th and 14th, 1923. The following programme has been arranged :—

On the Tuesday, at 11 a.m., members will meet at the Royal Technical College, George-street, Glasgow. The following papers will be read, or taken as read, and submitted for discussion :—(1) "Coal Dust as an Explosive Agent, with special reference to the Experimental Work of the United States Bureau of Mines," by George S. Rice ; (2) "Summary of Research Work carried out for the Committee on the Control of Atmospheric Conditions in Hot and Deep Mines" ; (3) "The Recent Search for Oil in Great Britain," by H. P. Giffard ; (4) "A Volcano in the Bathgate Coalfield of West Lothian," by H. M. Cadell ; and (5) "The Hurlet Sequence in Renfrewshire and Dumbartonshire and the Evidence of the Basin Structure in the Coalfields of Scotland," by David Ferguson. In the afternoon at 3.45 a visit will be paid to the works of Mavor and Coulson, Limited, Mile-end, Glasgow. At 7.30 p.m. there will be a reception by the Right Hon. the Lord Provost, Sir Thomas Paxton, Bart., and Magistrates in the City Chambers.

On the Wednesday at 9.15 a.m. the party will leave Queen-street Station of the London and North-Eastern Railway Company by special train to visit the collieries of the Fife Coal Company, Limited, in the Kelty district. After inspecting the Aitken Colliery and central power station, members will proceed to Lindsay Colliery, which has recently been converted from steam to electric power throughout, and the whole of the surface equipment is modern. They will subsequently visit Mary Pit, Lochore, where the sinking appliances—all electric—concrete headgear, permanent electric winder, and other features at the new shaft just completed, will be inspected. Members will then proceed to Cowdenbeath, where they will be entertained to luncheon by the Fife Coal Company, Limited. At 7.30 p.m. the dinner of the Institution will be held at the Grosvenor Restaurant, Gordon-street, Glasgow.

On the Thursday, June 14th, 1923, the party will leave Broomielaw Pier, Glasgow, by special steamer for an all-day cruise on the river and Firth of Clyde, at the invitation of the Scottish mineowners.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Whitsuntide Holidays.

BUSINESS in iron and steel has been very quiet this week and the weekly market in Birmingham was but poorly attended, many producers and consumers being still on holiday. Many of the Staffordshire ironworks have been closed down over the week, for they are rather badly off for orders. In the present state of demand, however, the output will not be seriously missed. Apart from the state of business, a number of ironworks closed down owing to the withdrawal of the water from the canal. The opportunity was, however, taken to carry out certain repairs and renewals. A number of the steel works commenced work at midweek. Though the trade outlook has improved by the settlement of the dispute in the building trade and the accommodation which has been reached by the flint glass manufacturers and the glass blowers, market conditions continue somewhat easy, and appearances would suggest a further period of quietness in the iron and steel trades of this district. Concessions are obtainable on most classes of finished and semi-finished material. Consumers are fairly well bought, and they continue to maintain that trade cannot expand on the present basis of prices, which they regard as artificial. Fuel suppliers are still in control of the situation, and prices of coke are maintained. Owners of idle blast-furnaces who have sounded the market this week are asked to pay as much as 33s. at ovens for deliveries of coke to begin in August. The demands of some South Wales collieries are even higher.

Steel Prices.

Though steel masters are loth to make price concessions, they have been forced in the case of some materials to meet consumers. There has been a readjustment as regards billets. Four-inch billets can now be bought at £8 15s., but, for general specifications, £8 17s. 6d. is the quotation. Higher grade billets for welding realise £9 5s. These prices are an effectual check to the renewal of business with the Continent, as the lowest prices quoted by Antwerp shippers this week would work out at something like £8 10s. delivered in this district. The uncertainties of the Ruhr position discourage the placing of new orders, many consumers considering that a settlement would liberate a good deal of continental steel at competitive prices. On the other hand, many of the large steel works decline to make any concessions, their order books being still in a satisfactory state, while they complain that prices are still too finely cut, occasionally leaving no margin of profit. In view of the heavy business being done in America, and the large amount of business known to be pending, merely awaiting the settlement of prices, the trade generally takes a rather hopeful view, scouting the idea that anything like a slump is to be looked for. Nevertheless, such movements as there are in steel are downwards. Welsh sheet bars are down to £8 10s. The sheet manufacturers have been disquieted by the refusal of consumers to buy forward, and this, it is understood, has weighed with the bar mills. Another factor is the reappearance on the market of French and Belgian basic pig. The lower prices for semi-finished material have reacted on several descriptions of re-rolled steel, small bars being obtainable at £11 and steel gas strip at £11 10s. For iron strip the price is round about £13, a margin which leads to a decided preference for steel for tube-making material. A fair inquiry is reported for structural steel, and prices are unaltered. Staffordshire steel hoops make £13 at works. Demand for light plates is fully upheld.

Wire and Tin-plates.

The wire mills constitute a bright spot. They are working in many cases at full capacity. The value of wire rods is represented by a quotation round about £13 10s. Tin-plate mills have dropped the basis by 10½d., the equivalent of the reduced price they are paying for bars. This reduction has, however, done little to stimulate business.

Pig Iron.

Pig iron prices are fairly maintained though some makers of North Staffordshire iron have reduced their quotations by about 5s. per ton, bringing them more on a level with those of Northamptonshire makers. The Staffordshire price has been very high for some time, 115s. being the quotation for foundry sorts, as against the Northamptonshire figure of 107s. 6d. But with smelters generally still fighting hard against market disintegration, there is no widespread break. It is only the prevailing high cost of fuel, however, that keeps pig iron at its present level. Producers would be pleased if conditions permitted of a reduction, for they realise that future business is withheld solely in the hope of easier terms being forthcoming. Consumers are encouraged in this attitude by the fact that gradually increasing outputs enable them to get deliveries of prompt iron, in small lots certainly, but sufficient to keep them going, for unfortunately their needs are not growing appreciably. Makers of pig iron are generally firm in spite of the falling off of new business. The furnaces booked heavily in February, and have still many unfinished contracts. A fall in the values of Scotch iron has checked some business with Glasgow at the Northampton furnaces, and it is understood that Cleveland, for the same reason, no longer supplies the Scotch market. Derbyshire makers maintain their quotation at £5 10s. at the furnaces for No. 3 iron. Forge iron is rather weaker owing to the poor demand from the Staffordshire ironworks. All questions of relighting furnaces in this district are suspended for the present in view of the continued high price of coke and the great uncertainty as to the future.

Manufactured Iron.

The Staffordshire bar mills, on the whole, are not too well employed, and many of them have been idle during the whole of this week. Makers of best quality bars, however, are fairly well off for orders, and prices are maintained at £14 10s. Keen competition for Crown bar business is stated to have reduced quotations below the £12 10s., which is recognised as the standard figure. No. 3 Belgian iron for the nut and bolt industry of Darlaston and the Black Country continues to cheapen, now being offered at £9 5s. delivered. There is no great demand for this in the present state of the nut and bolt trade, but the effect of such quotations is to depress farther the price of second quality Staffordshire iron. South Staffordshire makers, who quoted £11 10s. last week, now quote £11 7s. 6d., and consumers claim that in some cases offers of £11 5s. have been accepted. The Lancashire price has been lowered to £11 10s., which is stated to be the bare cost of production and carriage to the Black Country. The Belgians seem to be making some headway among nut and bolt manufacturers, for the industry has become quiet, competition is keen, and prices are cut so that makers are ready to take advantage of cheap raw material. Exporters are keen on getting business. It is hardly surprising, therefore, that home, made iron is bought sparingly, and only in such quantities as are absolutely essential to tide consumers over immediate needs.

Galvanised Sheets.

In spite of cheaper semi-finished steel and lower prices for spelter, galvanised sheets are maintained at £19 7s. 6d. to £19 10s., though here and there one hears of slightly lower prices being accepted. The local mills are very fairly employed.

Railway Mileage Tables.

Midland industrialists are keenly interested in the railway mileage tables covering all the systems in Great Britain, which have been prepared by the Birmingham Chamber of Commerce, and which are to be issued in book form for the use of traders and manufacturers provided the project receives sufficient support to justify the considerable expense involved. It has been urged for half a century past that such information should be made available, but hitherto only the railway companies themselves have possessed complete mileage tables. It has been a common cause of complaint amongst Midland and Staffordshire manufacturers that, though they had to pay freights on a mileage basis, they have had no ready means of ascertaining for themselves the cheapest way of forwarding goods to destinations outside their regular experience, and have been at a disadvantage in checking the accounts sent in by the railway companies. The object of the publication contemplated by the Birmingham Chamber of Commerce is to enable anyone possessing a general knowledge of traffic routes easily to compute the distance between any two points and to acquaint himself at the same time with any exceptional conditions such as bonus mileage.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

General Outlook.

IN consequence of the holiday there is little being done in Manchester, and the markets are all in a very uncertain condition. It is almost impossible to test prices in the absence of both buyers and sellers, but there is no indication of any coming improvement so far as the markets for iron and steel are concerned. The feature at the moment is a recovery in the competitive power of the continental makers, who seem to be seeking for orders at prices very far below anything that is possible in this country. It is indeed a puzzle to understand how it is that continental makers can work at the prices they are now quoting.

Metals.

Unlike the iron and steel markets, the market for the non-ferrous metals made a sharp recovery just before the holidays, which was rather startling in its character. The movement seems to have been initiated in America, but it is probable that the "bears" on this side had gone too far and were quick to take the alarm. There was a good deal of covering to be done in London, and it is not clear that this has all been effected. In Manchester the movement could not have much effect, because almost all the buyers of metals here were preparing for the holiday ; and in most cases they have the idea that the prices will be back again before they will need to do anything. Whether this is a right view to take is perhaps doubtful, for it is fairly certain that when standard copper had been depressed below £65 per ton, it was far too low. This was the time to secure cheaper supplies, and one finds it difficult to believe that so favourable an opportunity will recur. There is, however, not much reason for believing that copper has taken a permanent set upwards, for the output in America is still on the increase ; and although it is quite possible that American consumption will be fairly good, there is no indication at present that the European conditions are becoming more favourable. The French maintain that they are progressing in the Ruhr district, but one cannot believe that, with a sullen working-class population and a Government which encourages passive resistance, the industries of Germany can be got into working order. It is fairly certain therefore that the European consumption of copper must remain on the small side for some time to come. With regard to the manufactured copper prices, the reductions of £2 in sheets and ¼d. per lb. in tubes were made before the recovery, and probably no notice will be taken of the higher price for raw copper unless it should go very much farther than at present. Here dealers in scrap non-ferrous metals still take a gloomy

view, and are disinclined to make any advance in their buying prices. The fluctuations in tin have been rather sharp, and a movement of £10 per ton in the course of twenty-four hours is disconcerting. Merchants find it difficult to deal with orders in such a market, but, of course, this week there is very little to do. The market seems at the moment to be almost entirely in the hands of speculators, and consumers are holding off until the excitement abates. Lead and spelter have both recovered considerably from the lowest points reached. With regard to the latter, it is said that consumers in this country are buying more freely, but this may be checked with the return of higher prices.

Pig Iron.

The market this week is, of course, very quiet, as very few people are in business. The meeting at the Manchester Exchange was scarcely attended at all, and there was absolutely nothing done there. Attention is now directed to the position which will occur after the holiday. It seems probable that the Midland furnaces will then be very near the end of the orders which they have in hand, and will begin to feel some anxiety about the future. With pig iron at present prices it cannot be very safe to allow it to accumulate at the furnaces, and consumers here seem fairly confident that makers will begin to offer concessions in June. On the other hand, buying on the part of ironfounders has been restricted to a minimum for the last two months, and stocks of pig iron at the foundries cannot be large. While the present stringency in fuel continues, one cannot see how it will be possible for the furnaces to reduce prices sufficiently to satisfy consumers here; so we may see a kind of deadlock in June. Cleveland and Scotch iron seem a little easier, but there is no business here in either kind.

Finished Material.

The market here is absolutely without any business this week, but the feeling is rather weak. Those selling agents who are attending to business this week are not prepared to quote lower prices, and even if they were, there is no prospect of any new business until the holiday is over.

Scrap.

Dealers in scrap are very pessimistic just now. There is no demand for foundry scrap, and the small demand which existed for wrought and steel scrap seems to be failing again. The prices are irregular, but in the Lancashire district good cast scrap can be bought at 85s. per ton, heavy steel scrap at about the same price, and heavy wrought scrap at 95s. delivered.

The Engineering Trades.

It is not customary in the Manchester district to take work very seriously at Whitsuntide, and this year the holiday is more general than usual, owing to the general slackness in both the engineering and textile industries. A very large percentage of the works and factories have taken advantage of the trade depression to cut down the wages bills by giving their workpeople a full week's holiday, instead of part of the week, as is usual. One large engineering works at Oldham has, in fact, closed down for ten days. The few firms that are at all well off for orders closed on Wednesday or Thursday evening till Monday next.

BARROW-IN-FURNESS, Thursday.

Hematite.

The hematite pig iron trade, as far as business being transacted, is dull at present, and yet makers are not short of orders. They are well booked, and are likely to be fully engaged with the present number of furnaces for some time. Just when there appeared to be an end of coke shortage, there comes a surprise stoppage of three furnaces at Millom. The stoppage is only momentary, in a way of speaking, and it is somewhat remarkable that it should have occurred when the position as regards coke supply seemed to be easier. Probably there has been a sudden heavy shipment abroad which has robbed the local users, who are not prepared to pay heavy prices. This stoppage is very unsatisfactory and disturbing, for it suggests there is still a policy of hand to mouth having to be indulged in. The shipments continue, and pig iron last week left Barrow for Wales, Scotland and France (Treport). Prices are inclined to be easier, as one might expect with the market as it is to-day. Special qualities are being regularly delivered, and in this department there are orders for some time to come.

Iron Ore.

The iron ore trade remains about the same, and will continue to do so until there is an increase in the number of furnaces in blast. Only a moderate amount is going out of the district. Foreign ore is coming in in limited quantities, and there is not likely to be a great impetus given to this trade until there are more furnaces in blast.

Steel.

The steel trade continues to be moderately employed, and there does not seem to be much prospect of any brightening for a time. Barrow works are situated the best, with their rail, hoop and small bar mills engaged. Workington is not so busy. Foundries are moderately employed, with better prospects.

SHEFFIELD.

(From our own Correspondent.)

Basic Steel Boom Increases.

THE boom in basic steel, reported some weeks ago, so far from slackening, has become more intense, and users are complaining of inability to get their wants supplied promptly. The plants are on practically full time everywhere, and specifications to contracts are heavier than a fortnight ago. The pressure has stiffened the attitude of makers, who declare that a further advance in prices is more probable than a reduction. They feel confident that the buyers who have been holding off the market will now be compelled to place new business, more especially as the expected settlement in the Ruhr has not materialised. The bulk of work now on hand was booked at much lower prices than are now current. The same remark applies to pig iron. The supply of hematite iron is now ample, and prices have dropped several shillings from the highest point. Foundry and forge irons are quieter, but not quotably lower in price, with little or no actual business being done.

Acid Steel.

The better qualities of steel are not sharing in the boom to the same extent as basic, one explanation being that the lessening of the continental competition applies almost solely to the latter material. In the acid department activity has slowed down somewhat. Several of the firms producing for use in their own works cannot find occupation for the whole of their plant, because outside of railway business the demand for finished acid steel is quiet.

In the Finished Departments.

Business is far from satisfactory in the heavy steel foundries and forges, and at the local heavy engineering departments, which specialise on plant for iron and steel works. The railway steel departments continue to book work with satisfactory regularity, although the plants could turn out a good deal more than is coming forward. The pressure for cold rolled steel is as great as ever, and the damage caused by fire, this week, to the fine rolling mill at the works of Samuel Fox and Co., Limited, at Stocksbridge, will reduce a supply which has been on the short side for a long time.

The Russian Tool Trade.

Sheffield, which usually does a very fine trade with Russia in tools, is following with the keenest interest the international political situation between the two countries. It is felt here that a rupture of the commercial relations will have a very serious effect for a number of local firms. A year ago Russian orders for files, saws and tools were placed in the city to the extent of several hundred thousand pounds for which cash payment was given. Since then occasional orders have been picked up, and one or two large ones have been executed. Further recent inquiries would suggest that still larger orders may come along. That there will be no break in the relations between the two countries is devoutly hoped for in Sheffield.

The Cutlery and Plate Trades.

A somewhat paradoxical situation is just now noticeable in the Sheffield cutlery and plate trades. Whilst the very large firms, with world-wide reputations, are complaining of a good deal of slackness, the more compact, if smaller, firms report quite a busy time. Indeed, in the latter overtime is being worked, and orders are in hand which are calculated to keep the men fully employed for two months even should no fresh orders come to hand. The explanation is that the larger firms have not as yet cut down their overhead charges sufficiently.

Big Electrical Scheme Approved.

Last October the Sheffield Corporation, the electrical undertaking of which supplies current for light and power not only for city purposes, but also to the works, initiated a scheme for the establishment of a joint electricity authority for the north-east midlands. The areas and companies included in the scheme propounded by it comprised the city of Sheffield, the county borough of Rotherham, the borough of Chesterfield, the borough of Doncaster, the urban district of Mexborough, the urban district of Worksop, the Yorkshire Electric Power Company, the Derbyshire and Notts. Electric Power Company, the Sheffield and Rotherham Electric Supply Committee, the South Yorkshire Coal Trades Association, the Derby and Notts. Coalowners' Association, the Doncaster Collieries Association, the Lincolnshire Ironmasters' Association, the London, Midland and Scottish Railway, the London and North-Eastern Railway Company, and some small local authorities not supplying electricity. An inquiry was held into the proposal by the Electricity Commissioners, and, this week, the announcement has been made that with certain minor adjustments the area provisionally determined is approved. The position was reviewed by the Commissioners from various points; the trend of colliery and other industrial development eastwards from Doncaster; the possible need of a capital station on the river Trent, within a few years, for meeting the further requirements of the district as a whole; the potential development that might result from the establishment of such a station, and the existence at the present time of surplus supplies of waste heat at Frodingham and Scunthorpe. They express the opinion that the Yorkshire Electric Power Company should continue to operate within its statutory area in the north-east midlands district. With regard to the Derbyshire and Nottinghamshire Electric Power Company, the Commissioners also express the opinion that the company should be afforded an opportunity of developing its area, and that any question of exclusion should be left for future consideration when the occasion arises. The Commissioners give general approval to the technical scheme submitted by the Sheffield Corporation under which provision is made for the inter-connection of the municipal generating stations in the district; the installation of additional generating plant therein amounting to 20,000 kilowatts to meet the estimated growth of load, exclusive of railway and colliery demands, during the next four or five years; the extensions of the municipal stations at Sheffield, and the establishment, when required, of two further generating stations at Mexborough and Sprotborough.

Bridge Widening Contract.

At a special meeting of the Burton-on-Trent Town Council on Monday, tenders for the widening of the Trent Bridge, ranging from £78,432 9s. 1d. to £47,029 1s. 4d., were considered, and it was decided to accept the latter, which came from Gray's Ferro-Concrete Company, of Glasgow. A local firm, Messrs. Lambrick and Co., put in the second lowest tender at £49,928, and a resolution to give the contract to them was defeated. The bridge, which is over a quarter of a mile in length, is the gateway from Staffordshire to Derbyshire.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Trade Outlook.

WHILST the markets generally bear a very quiet appearance at the moment and everybody seems to be adopting a cautious policy in regard to commitments, the condition of Northern industry is much more healthy than it has been for some two years or more, and it is confidently believed that the period which lies immediately ahead will witness a further expansion of trade. Encouraging progress has been made in the iron and steel trades, and a favourable view is taken of the outlook. The world hunger for iron and steel, arising from the war and its long aftermath, is very far indeed from being satisfied, and there is a confident feeling in many quarters that a brisk revival will be experienced in the very near future. The question of prices is the chief obstacle at the moment, but there does not seem to be much hope of any substantial reductions while costs of production remain at the present high level.

Cleveland Iron Trade.

Another week of suspended animation has to be recorded in the Cleveland pig iron trade. The market, however, is less unsteady and not without an undertone of hopefulness. The general trend is towards increased consumption of pig iron, and as there is relatively little free iron, it needs only a revival of business on a modest scale to absorb all that makers have to offer. At the same time consumers still look for further cuts in quotations, notwithstanding the producers' persistent protest that current prices barely cover working expenses, and that in some departments actual loss is being incurred. Continental competition is disquieting, but a feeling prevails that conditions abroad will tend to check foreigners from selling in this market. Movements are being closely followed by both buyers and sellers here. There is a quiet confidence regarding the trade outlook, and the opinion is expressed that substantial orders that are being held up will be released so soon as there is reason to believe that prices have become stabilised. It is recognised that after a fairly long abstention from the market consumers must be getting short, and at least must buy to satisfy their immediate needs. There is consequently no disposition on the part of makers to cut prices, and the firmer tone of the coke market, which is still the dominating factor in the iron trade, seems to eliminate hope of cheaper pig iron. No. 3 G.M.B. is 124s.; No. 1, 130s.; No. 4 foundry, 120s.; and No. 4 forge, 117s. 6d.

Hematite Pig Iron.

Little change is reported in the East Coast hematite pig iron trade. Business is not brisk, but there is a good undertone. This iron is now being used freely for purposes for which foundry iron is customarily employed because of its continued comparative cheapness, and makers are succeeding in getting away most of their output. Thus the price is quite firm at 122s. 6d. for East Coast mixed numbers, and 123s. 6d. for No. 1.

Iron-making Materials.

At long last there is some inquiry for foreign ore, but the volume of business is still on the small side. Best Rubio ore is 24s. 6d. per ton c.i.f. Tees. Supplies of coke seem to be as scarce as ever. A number of makers are apparently over-sold, and ironmasters are experiencing great difficulty in getting delivery under contract to meet their urgent needs. The price of good medium furnace kinds ranges from 44s. to 45s. per ton delivered at the works.

Manufactured Iron and Steel.

Although business in the manufactured iron and steel trade remains quiet, the works are for the most part pretty comfortably placed in regard to orders and the lull is not looked upon as other than temporary. The Whitsun holiday spell at the works was confined to two days, operations being resumed on Wednesday. It is believed that to a large extent buying is checked by the situation in the Ruhr, and with this disturbing influence out of the way there is every reason to look for a resumption of demand on sound lines and for a steady expansion of business. The only unsatisfactory factor is the effect upon costs of production of the persistently high prices of fuel. Notwithstanding the lull in business, recent price levels are firmly maintained, there being no disposition on the part of manufacturers to make concessions.

The Coal Trade.

The Northern coal trade position generally is unchanged. Quietness is still the prevailing feature in nearly every instance, and as the month advances holders of various kinds appear anxious to clear their supplies, and are often disposed to discount the market, sometimes rather substantially. In business conducted directly with the collieries, however, there is no great change observable. The position of Northumberland steam coals is somewhat irregular for prompt. Though some of the collieries are very well stemmed, there are supplies of coal available and discounts can be obtained for most sorts. Gas coals are fairly steady and are maintained at recent prices, which remark also applies more or less to all kinds of bunkers.

Coking coals, however, are on offer, and lower prices are indicated at times for a quick clearance. It is expected, however, that the settlement of the harbour workers' strike at Hamburg and the ending of the strike at Antwerp will enable shipments to take place more regularly, and so benefit the Northern coal trade generally. The coke market is very steady for every class of foundry coke. There is a marked improvement in gas coke, which is in good demand, and is quoted higher in price.

SCOTLAND.

(From our own Correspondent.)

Quiet Outlook.

THE quieter conditions which set in some time ago have become more pronounced, until now the industrial outlook is anything but favourable. Consumers everywhere have been up against the prices quoted for almost all classes of material, while makers have been doing their best to maintain quotations on the plea of heavy costs of production. Consequently, dealings have been curtailed to within the smallest possible limits on home account, while overseas buyers have gradually reduced their orders. Prices of most materials are still nominally unchanged, but in many cases—in fact, where possible—makers are prepared to shade their charges somewhat for a very favourable specification. There is little doubt that not until there is a substantial decrease in prices will there be a satisfactory increase in orders generally. Increased offerings of cheaper continental material, if continued with satisfactory deliveries, must also be a strong factor in reducing home prices.

Poor Demand for Pig Iron.

The pig iron market is experiencing a dull period. There has been a considerable falling off in demand for hematite and foundry grades, both on home and export account, and a weaker tone is noticeable. Current prices are almost unchanged for small lots, but a decent-sized order can be placed on more advantageous terms. It is doubtful, however, if the best terms offered by makers at present would prove much of an inducement to consumers.

Uncertainty in Finished Steel and Iron.

A great deal of uncertainty exists in steel and iron circles as to the future, and the result is noticeable in the hesitancy on the part of both producers and consumers to enter into negotiations of any great importance. New business on home account has been restricted by the boilermakers' strike, while freer offerings of continental steel and iron have had a distinct effect. Thus, though many works have orders on hand enough to provide employment for a few weeks to come, prospects beyond that are very uncertain. In the steel trade new specifications for plates are very scarce, and there has been a substantial falling off in the demand for sections. The average export price for plates is £10, but a lower figure has been touched. The f.o.b. price for sections is round about £9 15s. per ton. Steel sheets almost maintain their firmness, owing to fair overseas inquiries, but these are not now so numerous. Reports from the bar iron works indicate approaching difficulties in respect to maintaining employment. Work on hand is nearing completion, and bookings have been very light of late. The home price of Crown bars remains at £12 10s. per ton, but the export quotation is at least 10s. less, and more than that for a good specification. The demand for scrap material has sagged of late, and a weaker tendency in prices is noticeable.

Coal.

The position in the coal trade also is undergoing a change. While the collieries are comparatively well off for business for this month, the prospects for June are not so bright. In the export market, many fewer inquiries for round coal are now in circulation, and though prices have already eased somewhat, a still further drop is likely unless an early spurt in business occurs. Overseas buyers are certainly holding off in the meantime, undoubtedly in the hope of cheaper prices. Washed materials are perhaps better, but an easier tendency is also apparent in the prices. Holders of fuel have been offering lots at reduced prices, but with only moderate success. Shipments from the East Coast ports are now more regular. Aggregate shipments from Scottish ports for the past week amounted to 342,235 tons, against 352,372 tons in the preceding week, and 290,123 tons in the same week last year. The home market for practically all classes of fuel is dull. Industrial demands are very low. Apart from the best qualities of house coal, there is very little fresh business reported.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

THERE is no change in the steam coal trade as compared with a week ago for the reason that the holidays have intervened. There was no work in the coalfield during the first three days of this week, and work at the docks was not resumed until Wednesday morning. Business has not yet settled down, and it is unlikely that there will be any operations of any account until next week, as colliery salesmen are so fully booked for this month that they are reluctant to add to their commitments because it will take a little time to recover from the curtailed output from the collieries during the past week. The majority of colliery undertakings are overstemmed, and through the delay in the loading of tonnage in dock their demurrage costs have, in many instances, been very heavy. A fair number of steamers were completed and sailed before the vacation, but a very considerable quantity of tonnage was compelled to wait over the holidays for their cargoes, and it looks as if the loading pressure for the remainder of this month will be as acute as it was before the vacation. It has been decided that the introduction of the partial third shift shall take place on June 4th. It was thought that to bring the scheme into force at a holiday time might dislocate arrangements rather than expedite shipments and, therefore, by commencing on Monday week it was considered that the revised working would stand a better chance of success. Exactly what the effect of the introduction of this partial third shift will have on the coal trade and prices it is difficult to say. The views held are somewhat conflicting. A full third shift is a different proposition to only working a third of the tips in the extra shift. Tonnage should certainly get quicker dispatch, and collieries as a consequence should secure the release of their wagons more regularly and be saved the necessity of occasionally cutting their prices to buyers who happen to have steamers in berth and can take spot coals. Coalowners undoubtedly take an optimistic view regarding the future, and while some of the collieries producing the superior qualities of Admiralty large are indicating that they might take 35s. for supplies for shipment over the second half of this year, there are others who decline to sell ahead at all. Until recently foreign buyers, especially those in Italy, which has been a very quiet market, have held off purchasing, but the last week or so has shown that there is more disposition to operate over the next six months.

Miners' Wages.

It is satisfactory to note that there is a good prospect of the miners in this district getting an advance in their wage rate in July next. It has been a long time coming, but judged by the Customs returns regarding the exports and values for the months of March and April, upon which the wages for July will be based, the chances of the miners getting an increase are looked upon as bright. The Customs returns are not the figures on which the official accountants base their calculations, as the auditors deal only with pit-head costs and the proceeds, but as far as can be seen the probability is that the advance in the wage rate will amount to 12 to 15 per cent. above the minimum at which wages have remained for nearly eighteen months.

Important Colliery Deal.

Negotiations have been proceeding and are practically completed regarding the transfer of the control of the firm of Cleeves' Western Valleys Anthracite Collieries, Limited, to Mr. T. P. Cook, of E. W. Cook and Co., of Swansea, in association with Sir Alfred Mond. It is understood to be practically certain that the deal will go through, and it involves a sum well in advance of £500,000. Messrs. Cleeves own collieries at Cross Hands, Tirydail and Llandebie, which produce the best grade of anthracite coal, and they also act as sales agents for the Cwmgorse and Cawdor collieries, in addition to which they own about half a dozen steamers. The output of the collieries which they control is approximately three-quarters of a million tons per annum, but taking into consideration the steam and anthracite coal which the firm handles as a merchant, it has an annual turnover of more like two millions. The firm of Cleeves and Co. was founded in 1892, since which time various changes have taken place, and in 1914 its enterprises were combined under the present title with a capital of £250,000.

Current Business.

Operations on the steam coal market this week have so far been negligible for the reason that the collieries have practically no free coal to offer for prompt shipment. They have a good deal of tonnage to load which was ready before the vacation, since which time other steamers have come to hand, and with outputs restricted by the holidays they are declining to entertain further business for the time being. The tone of the market is firm, but prices are more nominal than anything else. Best Admiralty large is about 42s. 6d., though some collieries are quoting more, while second qualities range about 40s. Small coals are scarce and best grade are about 32s. 6d. The Norte Railways of Spain are reported to have placed orders with three Cardiff export firms for a total quantity of 11,000 tons of steam coals for delivery at various ports in Spain before June 9th, while the Algerian State Railways have purchased from two firms about 50,000 tons of patent fuel. Negotiations are proceeding for substantial supplies of steam coals for other directions, notably South America. The anthracite market displays very little alteration. Large coals are rather on the quiet side, but sized coals and rubbly culm and duff continue in short supply and firm.

Latest News from the Provinces.

THE MIDLANDS AND STAFFORDSHIRE.

A Popular Midland Premier.

THE appointment of a Midland man as Prime Minister and First Lord of the Treasury in succession to Mr. Bonar Law gives much satisfaction to industrialists and business men generally in this district. Mr. Stanley Baldwin has been associated with the Bewdley Division of Worcestershire, where he is very popular, for a long period. He is well known on the Birmingham Iron and Steel Exchange, having big interests in the iron and steel trades as a director of Baldwins, Limited. He is recognised here as a man of ability and high principle, and his Premiership is very acceptable to manufacturers in the Midlands and Staffordshire.

NORTH OF ENGLAND.

Drop in Cleveland Iron Prices.

When the Cleveland pig iron market reopened after the holidays producers showed some keenness to enter into contracts, but sales were very few and values became distinctly easy. No. 3 G.M.B. Cleveland pig iron is now on offer at 122s. per ton, which represents a drop of 1s. 6d. on the figure quoted before the holidays. No. 1 is still firm and scarce at 130s., but No. 4 foundry is offered at 120s., and No. 4 forge is obtainable at 115s.

BRITISH WATERWORKS ASSOCIATION.

THE twelfth annual general meeting of the British Waterworks Association will be held in the Assembly Room, City Hall, Cardiff, on Wednesday afternoon, July 4th, and Thursday morning, July 5th, 1923. On the Wednesday afternoon, at 3 p.m., there will be a meeting in the Assembly Room, City Hall, Cathays Park, Cardiff, for the transaction of business and for the delivery of the presidential address, and in the evening at 7 p.m. there will be a reception at the Royal Hotel by the President and Mrs. Bird, followed at 7.30 p.m. by the Association's dinner.

On the Thursday morning, at 10.30 a.m., the following papers will be read and discussed at the South Wales Institute of Engineers, Park-place:—(1) Mr. Neil J. Peters, M. Inst. C.E., deputy waterworks engineer, "Wenallt High Level Storage Reservoir"; (2) Mr. H. W. B. Cotterill, A.M. Inst. C.E., resident engineer, "Llwyn-on Impounding Reservoir and Cantreff Roughing Filters"; (3) Mr. B. Santo Crimp, A.M. Inst. C.E., resident engineer, "Taff Fawr Section, Pipe Line No. 2"; (4) Mr. Cornewall-Walker, M. Inst. C.E., managing director, East Surrey Water Company, will open a discussion on "Main Roads Improvements"; (5) Mr. Atkey, J.P., chairman of the Nottingham Water Committee, and ex-President of the Association, will open a discussion on "The Need for Revision of Legislation on Water Supply Generally." In the afternoon visits will be paid to Wenallt storage reservoir, high-level supply, Rhubina high-level filters and service reservoirs, Lisvane and Llanishen storage reservoirs (chlorinating plant, Lisvane), Heath filters (open sand and pressure filters).

On Friday, July 6th, a visit will be paid to Llwyn-on impounding reservoir and other works now under construction, also the existing Cantreff and Beacons impounding reservoirs in the Taff Fawr Valley, 30–35 miles distant from Cardiff.

CONTRACTS.

THE tender of Gray's Ferro-Concrete Company, of Glasgow, for the widening of Burton Bridge has been accepted by the county borough of Burton-on-Trent.

VICKERS-PETTERS, Limited, of Ipswich, have recently received an order for two two-stroke 450/500 brake horse-power engines for installation in tugs to be used in Suez Harbour.

THE WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, Limited, of London and Chippenham, has received orders for Westinghouse brake equipments for 150 new coaches for the London Electric Railways.

THE D.P. BATTERY COMPANY, Limited, Bakewell, has just installed one of its latest type storage batteries at Stowe House, near Buckingham, which has just been converted from a country mansion to a public school. The battery was supplied through Messrs. Girdlestone and Co., who were responsible for the electrical work.

CATALOGUES.

DRUMMOND BROTHERS, Limited, Guildford.—Illustrated leaflet describing the Willing Worker concrete mixer.

HOLLINGS AND GUEST, Limited, Thimble Mill-lane, Birmingham.—A small eight-page pamphlet illustrating and briefly describing oil mill plant and seed baling presses made by this firm, primarily for use on overseas plantations.

SULZER BROS., 31, Bedford-square, W.C. 1.—A well-printed and displayed booklet on the Sulzer two-cycle Diesel marine engine. The construction of the engine is described in detail and various types of Sulzer Diesel-engined vessels are illustrated.

PROPELLING A CARGO BOAT.—Some time ago Mr. D. B. Morrison contributed to "The Story of Shipping," published by Sports and Sportsmen, Limited, an interesting chapter full of the romance of marine engineering, which bears the title of "Propelling a Cargo Ship," and which has now been reprinted in booklet form by Richardsons, Westgarth and Co., Limited. Beginning with the important question, What is a cargo boat? Mr. Morrison answers the question by saying that, broadly speaking, she is an engine-propelled vessel engaged in carrying the world's merchandise throughout all seas, and he then proceeds to describe in a simple and lucid way the development in ship propelling machinery which has been made since 1859, when single-expansion two-cylinder engines with flat-sided boilers working at from 20 lb. to 30 lb. per square inch with a consumption of over 4 lb. of coal per horse-power were used. The evolution of the marine reciprocating steam engine is traced and the economies resulting from the adoption of triple and quadruple-expansion with increased steam pressures are dealt with. An account of the early work of Sir Charles Parsons on the marine steam turbine is given, and the successive steps leading up to the large geared turbine installations of the modern ship are described. A considerable section is devoted to the internal combustion engine, and the relative advantages of both four-stroke and two-stroke Diesel engines are shown, special reference being made to the British developments. Reviewing the present position, Mr. Morrison seems to be of the opinion that, although the Diesel engine possesses great advantages from the point of view of lower fuel cost, the reciprocating steam engine will continue to hold its own for many a day in case of cargo ships of moderate powers engaged in trades where the cost of coal and oil are relatively comparable. Full advantage, however, should be taken of all improvements both in the generation of steam in the boilers and its use in the engines. For vessels of large power he considers that the steam turbine is at present unrivalled, and looks forward to a re-establishment of the reliability of geared turbines when the present difficulties are overcome. The advancement of the Diesel engine depends on its reliability in sea service and a reduction in fuel cost to within commercial limits. With these two essentials and an adequate supply of fuel oil at a competitive price the economy of the motor cargo ship is unassailed. The latter part of the book is devoted to illustrations of various types of engines, boilers, and auxiliaries built by Richardsons, Westgarth and Co., Limited.

Current Prices for Metals and Fuels.

IRON ORE.

N.W COAST—	
Native	26/-
(1) Spanish	24/-
(1) N. African	24/-
N.E. COAST—	
Native	—
Foreign (c.i.f.)	24/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	6 7 6	—
No. 1 Foundry	6 1 3	—
No. 3 Foundry	5 16 3	—
N.E. COAST—		
Hematite Mixed Nos.	6 2 6	6 2 6
No. 1	6 3 6	6 3 6
Cleveland—		
No. 1	6 10 0	6 10 0
Silicious Iron	6 10 0	6 10 0
No. 3 G.M.B.	6 2 0	6 2 0
No. 4 Foundry	6 0 0	6 0 0
No. 4 Forge	5 15 0	5 15 0
Mottled	—	—
White	—	—
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	13 0 0	—
North Staffs. Forge *	—	—
,, ,, Foundry	5 7 6 to 5 12 6	
(3) Northampton—		
Foundry No. 3	5 6	—
,, Forge	4 16 0	—
(3) Derbyshire—		
No. 3 Foundry	5 5 0 to 5 7 6	
Forge	5 0 0	—
(3) Lincolnshire—		
Basic	6 0 0 to 6 10 0	
Foundry	5 10 0	—
Forge	5 5 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.		
Hematite Mixed Nos.	6 15 0	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	12 10 0	—
Best ,,	—	—
N.E. COAST—		
Crown Bars	12 0 0	—
Tees	10 0 0	—
LANCS.—		
Crown Bars	12 15 0	—
Second Quality Bars	12 0 0	—
Hoops	15 0 0	14 15 0
S. YORKS.—		
Crown Bars	12 10 0	—
Best ,,	13 10 0	—
Hoops	15 10 0	—
MIDLANDS—		
Crown Bars	12 10 0	—
Marked Bars (Staffs.)	14 10 0	—
Nut and Bolt Bars	11 7 6 to 11 10 0	
Gas Tube Strip	13 0 0	—

STEEL.

	(6) Home £ s. d	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	13 0 0	—
Ship Plates ½in. and up	10 5	-
Sections	10 0 0	—
Steel Sheets ¼in. to ½in.	12 10 0	—
Sheets (Gal. Cor. 24 B.G.)	—	19 10 0

STEEL (*continued*)

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	10 10 0	—
Angles	10 0 0	—
Boiler Plates	14 0 0	—
Joists	10 0	—
Heavy Rails	10 10 0	—
Fish-plates	14 10 0	—
Channels	9 5 0	—
Hard Billets	10 15 0	—
Soft Billets	10 10 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	10 0 0	—
Light ,,	12 10 0	—
Billets	11 0 0	—
MANCHESTER—		
Bars (Round)	11 10 0 to 11 15 0	
,, (others)	10 5 0 to 10 15 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	13 15 0	13 10 0
Plates	10 7 6 to 10 15 0	
,, (Lancs. Boiler)	13 10 0	—
SHEFFIELD—		
Siemens Acid Billets	13 0 0	—
Bessemer Billets	13 10 0	—
Hard Basic	10 15 0	—
Intermediate Basic	10 10 0	—
Soft Basic	9 10 0 to 10 0 0	
Hoops	12 15 0 to 13 5 0	
Soft Wire Rods	13 0 0 to 13 10 0	
MIDLANDS—		
Small Rolled Bars	11 0 0	—
Billets and Sheet-bars	8 15 0 to 9 5 9	
Gas Tube Strip	11 10 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets (f.o.b. L'pool)	19 7 6	—
Angles	10 10 0	—
Joists	10 10 0	—
Tees	11 10 0	—
Bridge and Tank Plates	10 15 0 to 11 0 0	

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	23,9 to 24/-
Block Tin (cash)	197 5 0
,, (three months)	195 10 0
Copper (cash)	65 7 6
,, (three months)	66 5 0
Spanish Lead (cash)	25 2 6
,, (three months)	24 12 6
Spelter (cash)	29 5 0
,, (three months)	29 5 0
MANCHESTER—	
Copper, Best Selected Ingots	71 0 0
,, Electrolytic	77 0 0
,, Strong Sheets	104 0 0
,, Loco Tubes	0 1 2½
Brass Loco Tubes	0 1 0½
,, Condenser	0 1 2½
Lead, English	27 5 0
,, Foreign	26 5 0

FERRO ALLOYS.

(All prices now nominal.)

	Per Ton.	Per Unit
Tungsten Metal Powder	1/11 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23	10/6
,, 6 p.c. to 8 p.c. ,,	£21 0 0	8/-
,, 8 p.c. to 10 p.c. ,,	£20 0 0	8/-
,, Specially Refined		
,, Max. 2 p.c. carbon	£50 0 0	18/-
,, ,, 1 p.c. ,,	£60 0 0	21/-
,, ,, 0·75 p.c. carbon	£70 0 0	22/6
,, carbon free	1,6 per lb.	
Metallic Chromium	4/6 per lb.	
Ferro Manganese (per ton)	£16 for home.	
,, Silicon, 45 p.c. to 50 p.c.	£13 0 0 scale 5/- per unit	
,, ,, 75 p.c.	£21 0 0 scale 6/- per unit	
,, Vanadium	16/9 per lb.	
,, Molybdenum	9/6 per lb.	
,, Titanium (carbon free)	1/1 per lb.	
Nickel (per ton)	£130	
Cobalt	12/- per lb.	
Aluminium (per ton)	£82 to £100 (British Official.)	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	25/6
,, ,, Ell	27/3
,, ,, Splint	28/- to 30/6
,, ,, Trebles	28/6
,, ,, Doubles	27/6
,, ,, Singles	27/-
AYRSHIRE—	
(f.o.b. Ports)—Steam	25/6
,, ,, Splint	28/-
,, ,, Trebles	28/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	23/6 to 28/6
Screened Navigation	32/6
Trebles	28/6
Doubles	27/6
Singles	27/3
LOTHIANS—	
(f.o.b. Leith)—Best Steam	28/-
Secondary Steam	26/6
Trebles	28/6
Doubles	27/9
Singles	27/6

ENGLAND.

(8) N.W. COAST—	
Steams	31/6
Household	46/6 to 57/6
Coke	48/-
NORTHUMBERLAND—	
Best Steams	32/6 to 34/-
Second Steams	30/6 to 33/-
Steam Smalls	22/6 to 25/-
Unscreened	20/6
Household	25/- to 28/-
DURHAM—	
Best Gas	33/- to 35/-
Second	32/6
Household	25/- to 28/-
Foundry Coke	70/- to 72/6

SHEFFIELD—	INLAND.	
Best Hand-picked Branch	32/6 to 34/6	—
Barnsley Best Silkstone	28/- to 30/-	—
Derbyshire Best Brights	25/6 to 27/6	—
,, ,, House	23/- to 24/6	—
,, ,, Large Nuts	20/6 to 22/6	—
,, ,, Small ,,	18/- to 21/-	—
Yorkshire Hards	22/- to 24/-	—
Derbyshire ,,	21/- to 24/-	—
Rough Slacks	12/- to 14/-	—
Nutty ,,	10/6 to 12/6	—
Smalls	7/- to 9/-	—
Blast Furnace Coke (Inland)	24/- to 27/-	
,, ,, ,, (Export)	f.o.b.	44/- to 47/-

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	42/- to 43/-
Second ,, ,,	39/- to 40/-
Best Dry Large	38/- to 40/-
Ordinary Dry Large	35/- to 37/6
Best Black Vein Large	39,6 to 40·6
Western Valley ,,	39/- to 40/-
Best Eastern Valley Large	37,6 to 39/-
Ordinary ,, ,,	36/6 to 37/6
Best Steam Smalls	32/- to 33/-
Ordinary ,,	28/- to 31/-
Washed Nuts	35/- to 37/6
No. 3 Rhondda Large	38/- to 40/-
,, ,, Smalls	32,6 to 33,6
No. 2 ,, Large	34/- to 36/-
,, ,, Through	30/- to 32/-
,, ,, Smalls	26/- to 28/-
Coke (export)	65/- to 75/-
Patent Fuel	40/- to 42/6
Pitwood (ex ship)	30/- to 31/-
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	45/- to 47/6
Seconds	40/- to 45/-
Red Vein	32/6 to 35/-
Machine-made Cobbles	55/- to 60/-
Nuts	50/- to 52/6
Beans	45/- to 47/6
Peas	25/- to 26/-
Breaker Duff	12/- to 13/-
Rubbly Culm	17/- to 17/6
Steam Coals:	
Large	26/6 to 27/6
Seconds	25/- to 26/-
Smalls	20/- to 22/-
Cargo Through	22/6 to 25/-

(1) Delivered. (2) Net Makers' works. (3) At furnaces. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—F.O.B. Glasgow.

(8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b.

* Quotations extremely high and nominal.

French Engineering Notes.

(From our Correspondent in Paris.)

The Trade Future.

THE belief that the world's requirements for all kinds of metallurgical products were never so great as they are now and that heavy buying must take place as soon as the general situation becomes stabilised, is the one factor that encourages confidence under conditions that would otherwise bring about a serious collapse. The time will come when there will be so large a demand upon the resources of the metallurgical and engineering trades that manufacturers believe they will enter upon a long period of activity, but the recovery can only take place, so far as this country is concerned, when the present political and financial troubles are in a fair way of adjustment. On the whole, the situation would appear better than at any time since the French occupied the Ruhr. Coal and coke are coming into the country in increasing quantities, and there have been rumours of additional furnaces being put in blast, with the result that the prospect of obtaining larger supplies of iron and steel at lower prices encouraged buyers to enter the market. It is now seen, however, that, despite the more ample consignments of coke, there is no corresponding increase in iron and steel production, for blast-furnace proprietors know very well that there is a serious risk in depending upon reserves unless there is a certainty of supplies being continued, and the impression is gaining ground that all the reserves and stocks will be exhausted by the end of June. The immediate future therefore depends upon an early adjustment of affairs in the Ruhr, either by the French Government being able to arrange for a normal production of coke or by an undertaking being arrived at whereby Germany will cease the policy of "passive resistance." Meanwhile, iron and steel prices, which had a tendency to stabilise a little while ago, are hardening again, as the result of the continued exhaustion of stocks, and with the high prices of raw material and wages it has become almost impossible to do business except for pressing needs. As giving some idea of the situation, the cost of blast-furnace coke has more than doubled since the occupation of the Ruhr. No. 3 pig iron has increased from 255f. to about 450f. per ton and steel bars in the eastern district from 470f. to 740f. per ton.

The Joy Stick.

Soon after the Armistice, M. Esnault Pelterie brought an action against a number of aeroplane builders, as well as against the State, for alleged infringement of his patent rights in the "joy stick" control of aeroplanes, which during the war was employed by nearly everyone without thought of its being a valid monopoly. After a lengthy hearing, during which the aeroplane firms sought to prove anticipation and declared that if the patent were upheld it would mean the ruin of the industry, M. Esnault Pelterie obtained judgment in his favour. On appeal the judgment was reversed, and since that time the affair has gone from one court to another until what would appear to be a final verdict was given last week, upholding the claim of M. Esnault Pelterie to the "joy stick" patent. Consequently, the four firms which were proceeded against, together with the State, have been condemned to pay damages amounting to a total of nearly 7½ million francs. M. Esnault Pelterie will be remembered as the maker of the aeroplane bearing his name on which M. Latham accomplished flights which were regarded as remarkable at the time. It was, in fact, one of the precursors of monoplane construction. M. Esnault Pelterie announced a long while ago that any damages he obtained from an infringement of his patents would be devoted to the progress of aviation.

Brickmaking Machinery.

The machinery which began to be introduced four years ago for pressing all kinds of waste material into bricks was supposed at the time to be a temporary expedient for providing a cheap substitute for clay bricks, of which the supply was considerably below the demand. So far are the requirements from being met that the production of brick substitutes is larger than ever, and an extraordinary variety of machinery is being employed for the purpose, from hand presses to powerful brick-making machines. The object is, of course, to use local material, and thereby save the heavy cost of transport. Wherever slag is available, the bricks are declared to be durable, but some scepticism may be expressed in the case of many substitutes which are often moulded into blocks having the appearance of chiselled stone. As ordinary building material is lacking, a vast amount of these conglomerate bricks is being used for building, and the experience of the next few years should at least show what kinds of substitutes may be advantageously employed in the place of clay bricks. Meanwhile, the demand for cheap building material seems to be bringing good business to makers of machinery for moulding bricks with all kinds of conglomerates.

Electric Road Traction.

The future of electric traction on roads is regarded as offering considerable promise in view of the carrying out of the national electrification scheme. Every source of consumption must be made available if the scheme is to become a success financially, and by running heavy road vehicles it is hoped that the cost of current will be reduced to a figure which will allow of a great economy in electric road traction. Although little appears to have been done in increasing the storage capacity of batteries for a given weight, the manufacturing processes have, nevertheless, been improved, and the trials to be carried out in September next in Paris with electric vehicles are intended to ascertain the capacity and durability of batteries as made nowadays. No independent data have been obtained for many years past, not since the time the petrol engine almost completely entirely dethroned the electric motor for road traction. Similar trials are also to be carried out by the Institut Electrotechnique of Grenoble with light and heavy vehicles in view of the Exhibition of Electricity which it is proposed to hold in that town in 1925. It is hoped to organise the trials this year.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics

When an abridgment is not illustrated the Specification is without drawings.

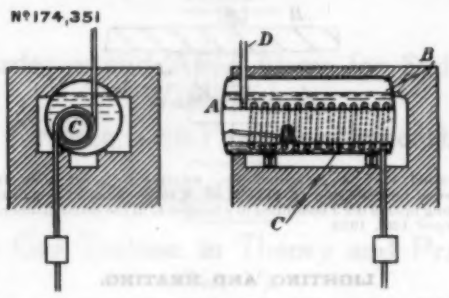
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

174,351. January 18th, 1922.—IMPROVEMENTS IN OR RELATING TO HIGH-PRESSURE STEAM BOILERS, Johannes Ruths, of Djursholm, Sweden, and Nils Hezekiel Frenne, of Stockholm, Sweden.

The boiler is filled to the level A B with a heat-transmitting medium, such as lead, zinc, &c., which is heated to a suitable temperature, such, for instance, as 400 deg. Cent., and in certain cases to a much higher degree. Placed in the transmitting liquid

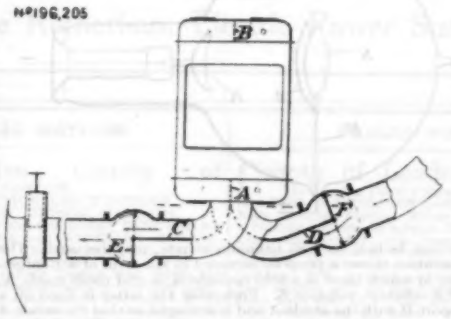


is the high-pressure boiler proper, consisting of the heating coil C. At the point D steam of any desired pressure is discharged at a temperature corresponding approximately to the temperature of the transmitting medium.—*April 18th*, 1923.

CONDENSERS AND FEED-WATER HEATERS.

196,205. June 1st, 1922.—SURFACE CONDENSERS, Schneider et Cie., No. 42 Rue d'Anjou, Paris.

In order to permit the circulating water to be shut off from either half of a surface condenser, so that the tubes of one half may be attended to while the other half is kept in commission,

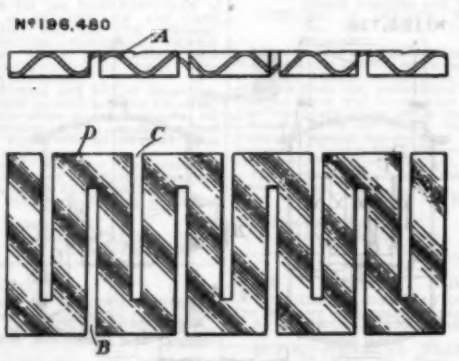


the inventors divide the water boxes by vertical partitions A and B. The inlet and outlet pipes are also divided by diaphragms C and D, while flap valves E and F are provided for shutting the water off from either half of the pipe.—*April 19th*, 1923.

SWITCHGEAR.

196,480. May 1st, 1922.—IMPROVEMENTS IN ELECTRIC RESISTANCE GRIDS, Robert Frederick Baerlocher, of 4, Arlington-road, West Ealing.

In the construction of resistance grids in accordance with this invention the metal used has corrugations as shown at A, which, when the grid is completed by the formation of the slots

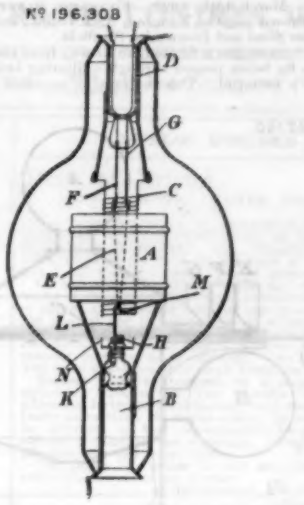


B and C, lie at an angle of approximately 45 deg. in relation to the slots. Grids constructed in accordance with this invention are said to have much greater strength than usual, particularly at the narrow portions D. An alternative construction is also described.—*April 26th*, 1923.

TELEGRAPHS AND TELEPHONES.

196,308. October 8th, 1921.—IMPROVEMENTS IN AND RELATING TO THE SUSPENSION OF INCANDESCENT FILAMENTS IN THERMIONIC VALVES AND THE LIKE, Stanley Robert Mullard and Mullard Radio Valve Company, Limited, 35, Claybrook-road, Hammersmith, London, W. 6.

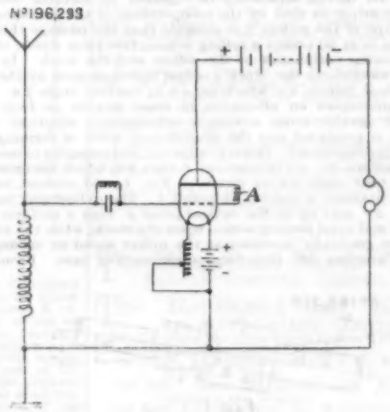
The anode A of the valve described in this specification is supported from a glass stem B, the grid C being supported from the stem D, which also serves to support the filament E through the wires F and G. One end of a helical spring H is attached by insertion through the hole K to an extension of one of the supporting stems B and the other is connected by a link L with a hooked end M, to which is attached the filament of the valve.



A wire N is fixed to the projection on the stem so that the free end or ends project towards the filament beyond the end of the spring. When a pull is exerted on the filament it causes the spring to expand, and in this particular example the length of the wire is so arranged that when the top of the helix H is level with the end or ends of the wire N the correct tension is on the filament.—*April 18th*, 1923.

196,233. December 19th, 1922.—IMPROVEMENTS IN OR RELATING TO THE RECEPTION OF WIRELESS SIGNALS, Alfred Louis Alexander Petty, of "Granada," Westcliff-on-Sea, Essex.

The object of this invention, which can be very briefly described, is to increase the intensity and clearness of wireless signals by increasing the rectifying power of the first valve. This

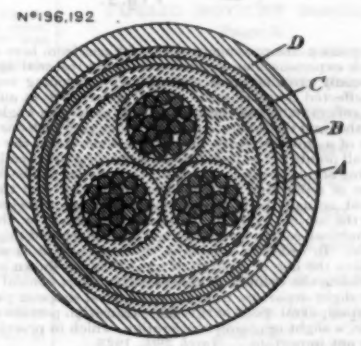


is done by providing a high-resistance leak circuit A between the anode and grid of the valve. The leak has a resistance of about 50 megohms, but the resistance varies with the constants of the circuit.—*May 2nd*, 1923.

TRANSMISSION OF POWER.

196,192. May 10th, 1922.—IMPROVEMENTS IN OR RELATING TO ELECTRIC CABLES, Callender's Cable and Construction Company, Limited, of Hamilton House, Victoria Embankment, London, E.C. 4; Samuel Ernest Roland Beecroft, of 81, Caledonian-road, Leeds, Yorkshire; and Alfred Hubert Horsfield, of 9, Grange-crescent, Leeds.

This invention has particular reference to lead-covered cables of the kind in which an insulated conductor or conductive layer is provided underneath the usual lead covering, but separated therefrom by a thin layer of hygroscopic and insulating material, this conductor or conductive layer being used for testing purposes in order to discover any holes or defects in the lead covering. The drawing shows a cross section of a three-core cable having the



usual insulation round the cores and between them and surrounding them all there is a layer of insulation A. Round the insulation A is a continuous lead covering B, which is preferably considerably thinner than the usual lead covering. Outside this lead test coating B is a layer C of insulating material of a hygroscopic nature and outside this is the ordinary lead covering D. The inner lead layer B is used in the well-known way to test for the presence of moisture due to any minute defect in the main covering D; but, as compared with other test layers, it is cheap

and easily applied and is itself continuous and water-tight. The cable may be provided, if desired, with a further metallic covering or armouring applied in the usual way outside the lead sheath D.—*April 19th*, 1923.

FURNACES.

196,160. March 13th, 1922.—Filtering Blast-furnace Gas, J. Brown and Co., Limited, A. J. Grant, and D. G. Jones, Atlas Steel and Ironworks, Sheffield.

Blast-furnace gas is filtered, on its way from the main A to the main B, by being passed through a filtering bed C of granular refractory material. This material is supplied to a travelling

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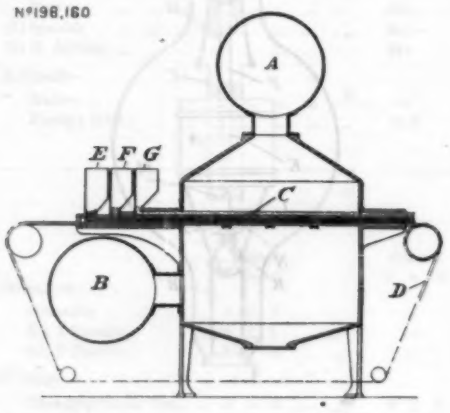


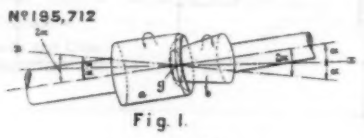
woven metallic belt D from hoppers E F G. The material in E is coarse and that in F and G successively finer. After having served its purpose the material is discharged by the travelling belt and is cleaned for re-use.—*April 19th*, 1923.

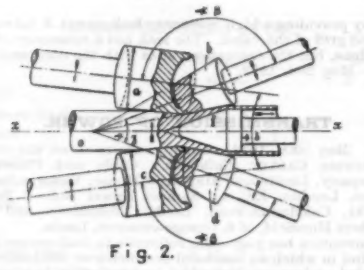
MACHINE TOOLS AND SHOP APPLIANCES.

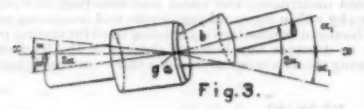
195,712. December 29th, 1921.—Rolling Tubes, Maschinenfabrik Sack G.m.b.H., Dusseldorf-Rath, and J. Gassen, Wahlerstrasse 11, Dusseldorf, Germany.

According to this specification, tubes are rolled by a mechanism in which the narrowing pass is formed by two cylindrical rollers and the widening pass by two conical rollers. Both pairs of rollers are driven separately or together by suitable toothed wheel gearing, so that by the co-operation of the arrangement and shape of the rollers it is possible that the passage through the pass is at all points a rolling action, free from stress, of the co-operating peripheries of the rollers and the stock. In this rolling mechanism the stock *s* is first operated upon by the two cylindrical rollers *a c*, which are set at the feed angle 2 *α*. The stock undergoes an alteration in cross section as from the original circular cross section a substantially elliptical cross section is produced and the preparatory work of forming the hollow is commenced. Directly adjacent and engaging in recesses in the rollers *a c* are two conical rollers *b d*, which are arranged at the feed angle 2 *α* as shown in Fig. 1, and enclose, in the known manner, a conical mandrel *f*. The cylindrical pair of rollers *a c* acts up to the central point *g* with a uniform tangential and axial feeding action upon the stock, while the rolling pressure gradually increases as the rollers stand at an angle *δ* to one another and thus form a contracting pass. From the

N°195,712







central point *g* the pass again opens out and from here onwards the stock experiences an extension in being restored again to a substantially circular cross section. The widening out of the pass is effected by setting the conical rollers *b d* at an angle *β* to the rollers *a c*. As the rollers *b d* make the angle *γ* with one another and the rollers *a c* make the angle *δ* with one another and are of a suitable shape and driven separately, the result is that at all points of the pass the condition of a practically stressless rolling action of the co-operating peripheries will be obtained. The line of separation between the rollers *a c* and the rollers *b d* would actually lie in the narrowest portion of the pass in the zone of the central point *g*. In such a case, however, the end of the cylindrical rollers would become very sharp and might tend to break. In order to overcome this difficulty it is advisable to displace the line of separation somewhat, as shown in Fig. 2, by providing the cylindrical rollers with a short conical portion. By this slight departure from the cylindrical shape of the rollers *a c* the peripheral speed of this short transition portion receives, as a rule, a slight opposing acceleration, which in practice, however, is not important.—*March 29th*, 1923.

195,901. July 11th, 1922.—Punching Machines, H. O. Bennie, Clyde Engine Works, Drumoyne-road, Govan, Glasgow.

In order to facilitate the setting of plates in punching machines so that the holes shall be punched in the proper places, the inventor allows a certain amount of backlash between the punch and ram, so that the punch may be brought down on to the plate lightly before the full pressure is applied. The punch A is attached to the plunger B by a coupling nut C. A collar is formed on the upper end of the plunger B and is made a sliding fit in the recess in the ram D. The weight of the plunger is supported by a spring E fitted between the collar and the adjustable gland F, this gland being screwed into the ram, which has an internal screw thread to receive it. The gland, after it has been

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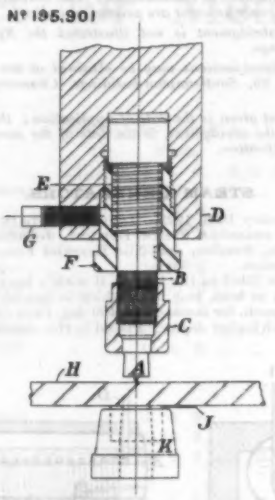

adjusted, may be prevented from rotating by a set screw G screwed into the ram D. The plate H to be punched is shown resting upon a die J contained in a bolster K in the usual manner.—*April 12th*, 1923.

LIGHTING AND HEATING.

187,613. October 18th, 1922.—Improvements in Electric Discharge Lamps, *The General Electric Company, Limited, of Magnet House, Kingsway, London, W.C. 2.*

According to this invention the body constituting the light radiator is transparent and is constituted by one individual crystal or a small number of crystals of thorium or other refractory oxide. The crystal or crystals may have a quantity of cerium dioxide or other coloured oxide, such as chromium oxide, on their surface, or, if desired, thin transparent layers of metallic

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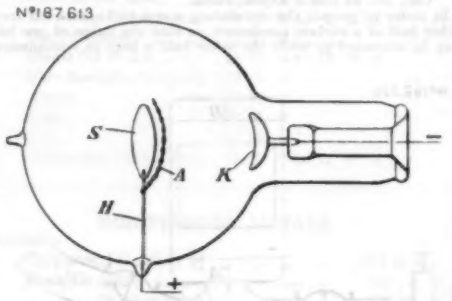


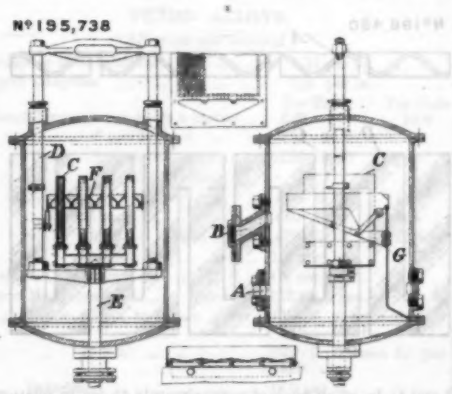
coloured bodies, such as titanium nitride, may be used. The illustration shows a lamp constructed in the form of a Röntgen tube, in which there is a cold cathode K, a grid mesh anode A, and a selective radiator S. Preferably the latter is fixed on a support H with the anode A and is arranged so that the anode A covers one side of the selective radiator S. The electrons emitted from the cathode K flow through the grid form anode A, bring the selective radiator S to incandescence, and then return to the anode A.—*April 19th*, 1923.

MISCELLANEOUS.

195,738. January 4th, 1922.—Filters, The Thermal Industrial and Chemical Research Company, Limited, and J. S. Morgan, 52, Grosvenor-gardens, London, S.W. 1.

In this filter slurry is supplied at A and steam at B. The filter plates C C are carried in a frame D that moves vertically. The plates are covered with filter cloths, while their interior spaces communicate with the hollow stem E. In operation the plates are lowered into the slurry and connected with an exhauster

N°195,738



through E. When a cake has formed on the filter cloths the plates are raised out of the liquid and the steam drives out the filtrate contained by the cake to exhaust. Steam at a higher pressure is then admitted at E to dislodge the cake, and the plates lowered for a repetition of the process. As the plates are lowered the scrapers F remove the cake and tip it into the hopper G.—*April 4th*, 1923.

196,199. May 18th, 1922.—Improvements in or relating to Electric Insulators, Arnold Morley Willis and Brecknell Munro and Rodgers, Limited, both of Thrissell-street Engineering Works, Bristol.

This invention relates more particularly to insulators of the cup and cone type employed on overhead wire systems for tramways, &c. The insulating cap is composed of a top part A and a lower part B. Into each of these parts is moulded a metal plate or washer, shown at E and F. The screwed spindle C passes through the two parts of the cap, its head D bearing on the

N°196,199

spring washer G, which in turn bears on the exposed surface of the plate E. The lower end of the screwed spindle is screwed into the line car, shown dotted. The plates or washers E and F are recessed to prevent them turning round with respect to the insulators.—*April 19th*, 1923.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Physical Society of London.—Imperial College of Science, South Kensington, S.W. 7. Papers: "The Effect of Torsion on the Thermal and Electrical Conductivities of Metals," by Professor C. H. Lees and Mr. J. E. Calthrop; and "The Use of the Wien Bridge for the Measurement of the Losses in Dielectrics at High Voltages, with Special Reference to Electric Cables," by Mr. A. Rosen. Demonstrations: "Experiment on the Production of an Intermittent Pressure by Boiling Water," by Professor C. R. Darling; and "A Novel Instrument for Recording Wireless Signals," by Dr. N. W. McLachlan. 5 p.m.

Royal Institution of Great Britain.—Albemarle-street, Piccadilly, W. 1. Discourse, "The Development of London," by Sir Aston Webb. 9 p.m.

SATURDAY, MAY 26TH.

Institution of Municipal and County Engineers.—Eastern District meeting at Southend-on-Sea. 10.45 a.m.

Institution of Municipal and County Engineers.—South-Western District meeting at St. Austell, Cornwall. 11.15 a.m.

MONDAY, MAY 28TH.

Institution of Automobile Engineers.—Loughborough graduates' meeting. The College, Loughborough. Paper, "The Design of Connecting-rods for High-speed Engines," by Mr. M. Platt. 7 p.m.

THURSDAY, MAY 31ST.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, W.C. 2. Annual general meeting. 6 p.m.

FRIDAY, JUNE 1ST.

Institution of Municipal and County Engineers.—North-Western District meeting. Town Hall, Rochdale. 2.45 p.m.

Royal Institution of Great Britain.—Albemarle-street, Piccadilly, W. 1. Discourse, "The Radiation of Light," by Professor H. A. Lorentz. 9 p.m.

TUESDAY TO FRIDAY, JUNE 5TH TO 8TH.

Institution of Electrical Engineers.—Summer meeting at Manchester. For programme see page 322.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

The American Society of Refrigerating Engineers has opened new offices at 35, Warren-street, New York, N.Y.

We are asked to state that Gaston Limited have been appointed sole agents for the Barb Engineering Company for the following districts:—London, Middlesex, Surrey, Sussex, Kent, Essex, Suffolk, Norfolk.

The United Oil and Coal Corporation, Limited, asks us to state that it has removed from 38, Victoria-street, S.W. 1, to Abbey House, Victoria-street, London, S.W. 1, to which it requests that all communications should, in future, be addressed.

We are informed that Mr. Bernard Brett has accepted an invitation to join the board of Brett's Stamping Company, which is the pioneer firm of the industry, founded by his father some thirty years ago. Mr. Brett, of course, retains the position of managing director of Brett's Patent Lifter Company and Powell Brett, Limited.

The English Electric Company, Limited, asks us to state that its offices at 2, Taviton-street, Gordon-square, W.C. 1, have now been permanently closed, and requests that all communications for that department should henceforth be addressed to its head office as follows:—The English Electric Company, Limited, Publicity Department, Queen's House, Kingsway, W.C. 2.

We understand that Mr. David Brownlie, whose address is 46, Grange-road, Ealing, London, W. 5 (telephone number, Ealing 2344), has, by amicable arrangement, severed his connection entirely with Brownlie and Green, Limited, of Manchester and London, and is now engaged in private practice as an advisory specialist in all matters relating to fuel economy.

Thornycroft Suction Gas Lorry.—In our issue of July 7th of last year an account of the Thornycroft suction gas lorry was given and its construction described. Later in the year this vehicle obtained the highest marks at the French trials, and since that time several lorries of the same type have, we understand, been completed for India and the Colonies. On the 9th of last month a 450-mile run extending over five days was made with a 4-ton lorry of this type under R.A.C. open competition rules. The route traversed was by Basingstoke, Gloucester, Chester, Warrington, Stockport, Newark, Stamford, St. Albans, returning to Basingstoke, a total distance of 458½ miles. The average speed of running time only was equivalent to 10.9 miles per hour throughout. Anthracite fuel was used in the form of beans passing through a 1in. mesh, and 1003¼ lb. were consumed, equivalent to 1025.7 miles per ton of this fuel. A small quantity of wood was used in addition for starting the producer. The water required for the producer was 31 gallons 7 pints, and a little over 1¼ gallon of lubricating oil were used. The total running weight of the vehicle with passengers and ballast was about 8 tons, and the weight of the gas producer equipment, including all accessories, 9 cwt. During the course of each day's run the dust collectors were emptied and the clinker removed from the fire-bars. These operations together took about twenty-seven minutes on each occasion.